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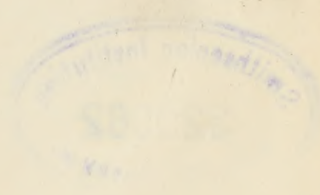
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MARCH, 1936

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J. D. SHERMAN, JR.  
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### FURTHER COMMENTS ON MELIPONA

BY HERBERT F. SCHWARZ

The present paper may be regarded as a brief supplement to the monograph on the genus *Melipona* (Schwarz, Aug. 16, 1932, Bulletin of the American Museum of Natural History, LXIII, Art. 4, pp. 231-460, Pls. I-X). It is based on specimens that have come under observation subsequent to the writing of that monograph.

**Melipona fasciata** subspecies **paraënsis**, variety **guerreroënsis**, new variety

♀. Differs from typical *paraënsis* in the coloration of the abdominal tergites, which, instead of being black or at least deep reddish brown verging on black, are sometimes wholly castaneous or black only on the more apically located tergites. Abdominal bands feeble, sometimes lacking. Bands bordering the sides of the mesonotum lacking.

Legs dark as in typical *paraënsis*. Maculations other than those noted and color of hairs the same as in typical *paraënsis*.

♂. Differs from typical *paraënsis* in respect to the same characters noted for the worker.

Clypeus with a narrow longitudinal stripe down its middle and an angular stripe of irregular thickness that zigzags around the apex and adjacent slanting sides of the clypeus.

In describing *Melipona fasciata melanopleura* Professor Cockerell, 1919, expressed the opinion that *melanopleura* "is possibly no more than a dimorphic variation of *costaricensis*." Later (1932) I discussed the instability of the abdominal coloration of *melanopleura*, indicating that in some of the specimens the basal tergites were light brown, the apical ones black,—a condi-

tion intermediate between the more uniformly maculated extremes represented by the dark *costaricensis* or typical *fasciata* on the one hand and *melanopleura* of brownish abdomen on the other. Similarly, in the paper of 1932, I pointed out a parallel series of transitions between *Melipona fasciata lateralis* and its color variant *kangarumensis*.

More or less the same degree of intergradation between the pure black and distinctly banded abdomen of *paraënsis* at the one extreme and the castaneous and indistinctly banded abdomen of *paraënsis guerreroënsis* at the other occurs among the Mexican specimens that I have assigned to the latter variety. In these intergrading specimens it is invariably the apical tergites of the abdomen that are dark and at least the two basal tergites that are wholly or largely castaneous. None of these Mexican specimens attains the uniformly black condition of the dorsal side of the abdomen which, except for the basal concavity and the bands, is characteristic of typical *paraënsis*, while in many of them the tergites are wholly castaneous.

The specimens on which the present variety is based include a number of workers from localities in the state of Guerrero—Tierra Colorada, 2000 ft., Rincon, 2800 ft., Tepetlapa, 3000 ft., Amula, 6000 ft., Xucumanatlan, 7000 ft., Omilteme, 8000 ft. There is also a male from Chilpancingo, 4600 ft., in the same state, collected in October, and one from Omilteme. All of the Guerrero specimens were obtained by H. H. Smith and were kindly lent by the British Museum. To the British Museum I am indebted also for a worker from Oaxaca and two specimens from Orizaba,—one of them a male, Dec. 1887, from the Godman-Salvin collection. The specimens lent by the British Museum have been supplemented by six specimens, all workers, collected by H. E. Hinton and R. L. Usinger at Real de Arriba, District of Temascaltepec, 6370 ft., in the southwestern corner of the State of Mexico, about 100 miles southwest of the City of Mexico. In all of the bees from the last-mentioned locality the abdomen is pure castaneous without admixture of black. Dr. Usinger, to whom I am indebted for the opportunity of examining the specimens from Real de Arriba, writes that they were domesticated and that the nest was in “an upright log, with a small box for a ‘super.’”

Type material in the British Museum, California Academy of Sciences, and American Museum.

**Melipona fasciata melanopleura and *M. f. belizeæ***

In 1932 I described as a subspecies of *M. fasciata* an insect from British Honduras which I name *belizeæ*. I assigned to it sub-specific rank on the basis of the fulvous hairs of its thorax and vertex, its yellow scutellum and axillæ, and other characters. In these respects it differs from its close relative in Costa Rica, *melanopleura*, which has black hairs on vertex, mesonotum, upper two-thirds of mesopleura, scutellum, and axillæ, and which has the chitin of the scutellum and axillæ black or dark reddish.

Since the paper in question was published I have had opportunity to examine specimens, kindly loaned by the British Museum, from Teapa, State of Tabasco, Mexico, collected in February by H. H. Smith, and from several localities in Guatemala—Senahu and Chacoj in Vera Paz and Mirandilla—collected by Champion.

The specimens from the State of Tabasco align themselves with *belizeæ* but the specimens from Guatemala are rather intermediate between *melanopleura* and *belizeæ*. Those from Senahu and Mirandilla have the yellowish scutellum and axillæ of *belizeæ*, but the hairs of the vertex and mesonotum, while not wholly black, are often predominantly of that color as are those of the upper part of the mesopleura, approximating in these respects *melanopleura*. Guatemala would seem to be the meeting ground of the fulvous haired *belizeæ* from the north and the dark-haired *melanopleura* from the south, with a resulting instability of coloration.

**Melipona schencki subsp. *picadensis* (Strand)**

♀ (Gravid). Head somewhat smaller than that of the worker and with finer sculpturing and greater resulting shininess. The hairless clypeus especially shiny, with sparse, irregular punctation over most of its surface, but finely tessellate or punctate-tessellate here and there along its basal, apical, and lateral margins. Front finely and rather densely tessellate; the vertex with ultra-fine tessellation, semishiny. The malar space much longer than in the worker, the shortest distance between the rim of the eye and the base of the mandible being about one-third of the width of the mandible at the base. The mandible more arcuate along its outer surface than is the

basally rather straight mandible of the worker. The upper part of the head black; the clypeus castaneous with a rather broad but diffuse and ill-defined, ferruginous maculation bisecting it longitudinally, and two somewhat more clearly outlined, faded yellowish spots, one in each of the lower lateral extremities of the clypeus; the labrum and the mandibles, except for their darkened apical edge and black basal prominences, a faded, whitish yellow; the supraclypeus ferruginous; a castaneous area fills the space between the clypeus and the eye and extends upward attenuated along the inner orbit of the eye about half-way to the summit. The long hairs of the front brownish to blackish; those of the vertex and cheeks black; those fringing the mandibles below and the labrum stramineous.

The thorax much less closely sculptured than is that of the worker, shiny both on the mesonotum and mesopleura due to the fact that the tessellation is finer or has been erased or replaced by small punctures with intervening smooth spaces. The thorax black except for the tawny axillæ and scutellum. The long hairs of the thorax unfortunately more or less matted and discolored due to moisture and their original color, therefore, somewhat difficult to interpret. On the mesonotum they appear dark, possibly approaching the black condition of those of the worker, but on the mesopleura and especially on the scutellum the hair appears tawny, departing in this respect from the condition of the worker of subspecies *picadensis* and inclining to the condition of the typical subspecies.

The legs blackish, with a ferruginous area at the apex of all the femora. The hair of the legs not so uniformly dark as it is in the worker. There are black hairs on the external surface of all the tibiæ, almost exclusively so on the middle and hind tibiæ, and on the hind femora black hairs predominate. The other joints of the legs with for the most part grayish to yellowish hairs; the metatarsal brushes a little more golden. The hair of the legs rather long and coarse. The hind tibiæ without the lateral fringes characteristic of the worker, not quite so wide as in that cast, with the posterior part of the apex rather rounded instead of definitely angulate.

The wings very short compared with the length and bulk of the body, even shorter than in the worker, hyaline faintly tinted with yellowish, of slightly stronger stain in the basal part. The venation and tegulæ ferruginous.

The abdomen much extended and swollen, deep castaneous to blackish, but with a rather broad, clearly defined, pale yellow, hairless area on tergite 3 separating a basal area of castaneous from an apical area of castaneous. Tergite 1 rather closely tessellated and covered, more densely at the sides than toward the middle, with somewhat woolly, brownish yellow hairs. Tergite 2 seemingly shorter than the subsequent tergites and therefore with its base probably incompletely revealed. The portion of the base that shows on tergite 2 is a smooth, hairless, pale yellowish area like that described for tergite 3; the apex of tergite 2 (perhaps the only part exposed in the virgin queen) is hairless and virtually smooth (with ultra-microscopic transverse ridges) on its upper half and with rather coarse punctation and fringing hairs on its lower half. The basal castaneous region of the fully exposed tergite 3



densely tessellated and closely covered with grayish to brownish feathery tomentum, the median area of yellow hairless, the apical castaneous area punctate and with rather long, yellowish brown hairs. Tergites 4 and 5 similar in their sculpturing and in the color and distribution of their hairs to tergite 3; however, there is no yellowish median area on tergites 4-5 but at most an area of a little paler brown which, contrary to the condition on tergite 3, is punctate and somewhat hairy, constituting a transition rather than a division between the basal and the apical areas. Tergite 6 somewhat less exposed, with the extreme base concealed; like the preceding tergites it has long, yellowish hairs in the apical region.

Length 10 mm. (of which the abdomen occupies 6 mm.); width of thorax  $3\frac{1}{4}$  mm.; length of forewing, including tegula,  $6\frac{1}{4}$  mm.

♂. The face very much narrower than in the worker or the queen, with the lateral extremities of the clypeus almost in contact with the rim of the eye instead of being far removed from it as in the worker and especially in the queen. The facial maculations far more distinct than in either the worker or the queen. The entire clypeus is pale yellowish except for two faint, subparallel, longitudinal, brownish stripes and brownish suffusion along the apex; the side-facial maculations, extending half-way up along the inner orbit of the eye, broad below, attenuated above, are likewise light yellow; the supraclypeal area more invaded by brown. The mandibles hour-glass shaped, black, with a ferruginous apex. The hairs of the head long and black, those fringing the mandibles below and those of the vertex especially long, those on clypeus, front, and cheeks only a little shorter, those on the labrum and scape distinctly shorter; in addition to the longish, black hairs there are shorter, grayish, plumose hairs on the front. The clypeus punctate-tessellate; the front densely tessellated, dull; the vertex a little more lightly tessellated, with a faint sheen.

The mesonotum, mesopleura, and propodeum densely tessellated and dull, the scutellum slightly shiny but with a fairly close granular punctation. The scutellum is deep reddish verging on black; the mesonotum and the other areas of the thorax black. The hair of the mesonotum, scutellum, and mesopleura black. An encircling fringe of hairs on the tubercles whitish.

The legs covered almost exclusively with black hairs but the hairs on the under side of the coxæ and trochanters largely pale, and the metatarsal brushes golden. The hind tibiæ considerably narrower than in the worker, their somewhat rounded instead of posteriorly angular apex about as wide as the rather parallel-sided basitarsi.

The wings hyaline, faintly stained with yellow; the venation stigma, and tegulae ferruginous.

The tergites of the abdomen densely hirsute but the hairs not so predominantly black as in a worker from the same locality, whitish hairs largely replacing black on the sides of tergites 1 and 2 and even over the middle of tergites 3 and 4 while tergites 2 and 3 have whitish fringes.

Length 9 mm.; width of thorax 4 mm.; length of forewing, including tegula,  $7\frac{1}{4}$  mm.

The above descriptions, based on specimens lent by the British Museum, are given in some detail because this subspecies has been described up to the present only from the worker.

The queen of *schencki picadensis* has not so great a preponderance of dark hairs as have the worker and the male, and in the partial replacement of black hairs by fulvous inclines somewhat to the coloration of the typical subspecies. It is to be noted that the queen of typical *schencki* has light hairs in certain areas where the hairs of the worker are black, so that the queens of both subspecies manifest a somewhat parallel tendency. The queen of *picadensis* has, however, far more dark hair than the queen of typical *schencki*, which has the hair of the head, thorax and abdomen rather uniformly straw-yellow and only on the legs has darker admixture.

The coloration of the hairs of the abdomen is very variable in *schencki picadensis*. The male above described has the abdominal hairs at variance with those of a worker from the same locality and, although this worker probably approximates the coloration noted by Strand in his description, both are in turn rather at variance, in respect to the coloration of the abdominal hairs, with workers I described in 1932.

The queen of *schencki picadensis* here described was collected, together with workers, by R. von Ihering, in Rio Grande do Sul, southern Brazil. The male and a worker were obtained at Theresopolis, presumably the locality in the State of Santa Catharina, southern Brazil.

#### **Melipona schencki** subspecies **schencki** (Gribodo)

Among specimens submitted for identification by the British Museum there are workers of the typical subspecies of *schencki* from the following localities:

Guaruja, Ilha Santo Amaro, April 8-13, 1912 (G. E. Bryant);  
Paraná (E. Dukinfield Jones).

## NEW MIDGES ON PINE AND GRASS

By E. P. FELT

BARTLETT TREE RESEARCH LABORATORIES, STAMFORD, CONN.

There was a mysterious though scattered injury to pine needles on the Laboratory grounds in 1932. The following year this was definitely associated with a gall midge larva. The white pine and Scotch pine were the species affected. An individual maggot was found at the very base of the needle bundle, the infestation being easily recognized by a slight discoloration, later a yellowing, especially on Scotch pine, also by the readiness with which needles were picked from the branch. An infestation occurred on a small white pine at North Stamford and by the last of June there was possibly 80 to 90 per cent of the foliage killed, the infestation evidently progressing outwardly on the tips with the development of the new needles. The work of the insect was also observed on Scotch pine at the Cross River Reservoir, a little north of Bedford, New York.

Infested needles collected the last of June, 1934, were carried over and the first midge emerged May 28, 1935, the insects issuing in numbers early in June. The first infested needle bundles were observed June 25 and on July 5 many full grown larvæ were found. The maggots drop and winter in the debris on the ground. The work of this insect is very similar to that depicted for *Cecidomyia brachyntera* Schwagr., and the adults agree in a general way with the illustrations for this insect, though it is impossible from available descriptions to be certain that the two are identical and the insect is therefore described below as new.

### *Itonida pinifolia* new species

MALE. Antennæ about one-half longer than the body, rather thickly haired, dark straw, basal segments yellowish, the fifth with stems two and one-fourth and two and one-half times their diameters respectively; basal enlargement subglobular, with a whorl of stout setæ and a subapical circumfilum, the loops extending to the base of the pyriform distal enlargement, the latter with a length one-half greater than its diameter, a subapical, stout

whorl of stout setæ and sub-basal and subapical circumfila, the loops moderately stout; terminal segment having the basal portion of the stem with a length about five times its diameter, the distal enlargement subcylindrical, with a length three times its diameter, somewhat swollen basally and apically and with a tapering, apical process with a length nearly three times its diameter. Palpi, first segment short, the second and third subequal, with a length about three times the width, the fourth one-half longer than the third. Mesonotum dark orange, the submedian lines pale orange; scutellum dark orange, postscutellum and abdomen reddish-orange. Wings hyaline, the third vein uniting with costa well beyond the apex. Halteres, coxæ and femora pale orange, paler basally, the femora distally, tibiæ and tarsi mostly pale straw, except that the third, fourth and fifth segments of the posterior tarsi are lighter, the third and fourth being narrowly ringed distally with fuscous. Claws simple, rather strongly curved, the pulvilli rudimentary. Genitalia pale yellow, basal clasp segment short, stout, terminal clasp segments moderately broad and tapering; dorsal plate short, deeply and triangularly emarginate, the lobes broad, ventral plate short, broad, broadly and roundly emarginate.

FEMALE. Length 2.5 mm., antennæ about three-fourths the length of the body, sparsely haired, dark straw, the fifth segment with a stem one-fourth the length of the cylindrical basal enlargement, which latter has a length about two and one-half times its diameter. Terminal segment cylindrical, with a length three times its diameter and apically with a conical tip, having a length about one-half greater than its major diameter. Palpi, first segment oval, the second to fourth slender, the last with a length four times its width; mesonotum reddish-brown with pale orange submedian lines; scutellum and postscutellum pale orange; abdomen a nearly uniform reddish-orange; wings slightly cloudy; ovipositor pale straw with a length about one-half that of the abdomen, the terminal lobes broadly oval. Other characters as in the male.

LARVA. Length full grown 3 mm., moderately stout, pale yellowish or yellowish-orange; head broadly triangular, the antennæ short, two-segmented; the breastbone bilobed anteriorly, tapering to a point, brown, the body smooth, the posterior segment with a pair of stout, conical up-curved, fleshy processes.

A series of gall midges reared from *Phragmites communis* by Dr. Paul S. Welsh, of the Zoology Department of the University of Michigan, together with some additional material, was received from Dr. Harold Morrison, of the Bureau of Entomology and Plant Quarantine. There is at hand no description of the gall or deformity in which the insect occurred, though this was presumably an aborted bud-like shoot. Most of the material bore



the label "Maple Bay, Douglas Lake, collected October 2, 1934 and reared May 2, 1935." Other material was labelled "Oak Harbor, Ohio, 7, 9, 1928, reared by H. G. Walker from cocoons in *Phragmites*." Another adult was reared from a larva collected at Crooked River, Michigan, Cherboygan County, October 8, 1934, issuing April 28, 1935.

This interesting species, on account of its markedly reduced palpi, is referred to the genus *Asteromyia*, and is presumably related to *Asteromyia agrostis* O.S., from which it is easily separated by the greater number of antennal segments in both sexes and the silvery spotted, instead of white-margined abdominal segments.

***Asteromyia phragmites*, new species**

MALE. Length 1.25 mm., antennæ extending to the base of the abdomen, dark brown; twenty-one sessile segments, the fifth with a length a little greater than its diameter; terminal segment ovate, broadly rounded apically and with a length about three-fourths its diameter; palpi, first segment short, quadrate, second about as long and the third slender, one-half longer than the second; mesonotum dark reddish brown; scutellum and postscutellum dark brownish yellow; abdomen dark brown with rudimentary sublateral patches of silvery scales on each abdominal segment; wings thickly scaled along the anterior margin and with a distinct white spot at the union of the third vein and costa; halteres pale yellowish basally, fuscous apically, coxæ and femora basally pale yellowish; tibiæ and tarsi mostly light straw, the posterior tibiæ and tarsi somewhat darker, except the pale yellowish fourth and fifth tarsal segments; claws strongly curved, unidentate, the pulvilli as long as the claws.

FEMALE. Length 2 mm., antennæ extending to the base of the abdomen; dark brown; twenty-six antennal segments, the fifth with a length a little less than its diameter; terminal segment oval with a length a little greater than its diameter; mesonotum dark reddish brown with white, silvery scales on the submedian lines; scutellum whitish transparent; postscutellum fuscous yellowish; abdomen dark brown, the segments with indistinct submedian, silvery patches; ovipositor nearly as long as the abdomen, the terminal lobes slender, with a length five times the width; other characters about as in the male.

Types deposited in the United State Museum of Natural History.

*The Biology of Mayflies With a Systematic Account of North American Species.* By James G. Needham, Jay R. Traver, Yin-Chi Hsu, assisted by specialists in certain subjects. Ithaca, New York, Comstock Publishing Company, Inc., 1935. XVI + 759 pp., 42 pl., 165 fig., col. front. \$7.50.

It is 137 years since Dr. Hugh Williamson read before the American Philosophical Society his description of and observations on *Ephoron leukon*, apparently the first American mayfly to be described. Previous to that time, or in 1749, John Bartram, the botanist, had made some observations that were published a year later in the Transactions of the Royal Society of London. Following these two men, Thomas Say described some, then Hermann A. Hagen and Benjamin D. Walsh. These men were the early workers. After Hagen's "Synopsis of the Neuroptera of North America" with its 45 species of mayflies, in 1861, there came in 1892 Nathan Banks' "Catalogue of Neuropteroid insects" with 86 species and in 1907 his second catalogue with 102 species. Now we have a work by Dr. Needham and his colleagues containing descriptions of 507 species, forty-eight of which are new to science. And the authors, after bringing together in 739 pages not only their own work and observations but all the contributions of other workers, modestly hope that the little that is presented about this neglected order will form a substantial basis for future work. There is no doubt about their work being a substantial basis for future activity, nor of the stimulating effect it will have on students, but I fear that many years will pass before the entomological world will have a more comprehensive work than the present one. Approximately one-third of the book is occupied with chapters on life-history, structure of the adult and nymph, internal anatomy, postembryonic development, eggs and egg-laying habits, embryonic development, taxonomic characters of the adult, studies on the wings, legs, the body wall of the thorax, the musculature of the thorax, nymphal structures and adaptations, the evolution of mayflies, enemies, collecting, rearing and preservation. The remaining two-thirds of the book are concerned with classification, redescriptions, descriptions of new species, keys to adults and nymphs and verification tables that supplement the keys, together with a bibliography and index.

The book should appeal to collectors, teachers, taxonomists, anatomists, and students of entomology in general, because it is the most exhaustive and adequate monograph on all aspects of the North American Ephemeroptera that has ever appeared.

H. B. W.

## THE LIFE HISTORY OF SERICA SERICEA (ILL.) (SCARABÆIDÆ-COLEOPTERA)\*

BY CLARENCE H. HOFFMANN

UNIVERSITY OF MINNESOTA, ST. PAUL, MINNESOTA

Although the genus *Serica* MacL. has received considerable attention taxonomically, little has been written concerning the biology of members of this genus. Grubs of certain species of this genus may be of considerable economic importance inasmuch as they have been found associated with *Phyllophaga* grubs attacking the roots of coniferous seedlings in northern Minnesota. The adults, on the other hand, cause damage by defoliating many kinds of plants.

I am indebted to Dr. C. E. Mickel for calling my attention to an outbreak of *S. sericea* in Anoka County, Minnesota, to Dr. R. W. Dawson for making determinations within the genus *Serica*, and to both of these gentlemen for aid in making some of the collections during the three years this study was in progress.

**HABITAT.** The site of the *S. sericea* infestation studied was an upland, burned-over area in Anoka County, near Anoka, Minnesota. Previous to the time it was cleared and burned over to provide better pasturing facilities, this area was a deciduous woods. It is flanked by Coon Creek on one side and what was once the Mississippi River bed on the other. The vegetation of this area consisted chiefly of a rank sucker growth arising from cut oak stumps, many grasses, and an abundance of hazel shrubs well embedded in the sandy soil.

On the night of May 12, 1932, the three of us collected approximately 600 adults of this species between the hours of seven and nine o'clock. Most of the beetles were feeding on the newly emerged oak leaves which were arising from sucker growth, the shoots of which seldom exceeded two feet in length. Defoliation was severe on much of this secondary growth, but slight on the large oak trees adjoining the burned-over area. Although the

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beetles seemed to prefer oak leaves, they feed extensively on the leaves of nearby hazel shrubs.

About a year later, May 16, 1933, Dr. Dawson and I in one and one-half hours' time captured 475 adults feeding on oak and hazel leaves. As many as 66 individuals of *S. sericea* were collected from the shoots encircling a single oak stump. Larvæ of this species were found associated with the roots of hazel and oak, especially with hazel roots. One small hazel shrub uprooted on September 15, 1932, yielded 10 larvæ, all of which were within the upper three inches of soil among the anastomosing roots.

**HIBERNATION.** This species overwinters in three different stages, namely, as a first-year grub, as a second-year grub, and as an adult. Diggings made September 19, 1933, revealed first and second-year grubs, as well as recently emerged adults, in the upper 17 inches of soil surrounding hazel roots. The larvæ in the upper 8 inches of soil were quite active, whereas those at greater depths were inactive. Seven adults, three males and four females, were taken at a depth of 14 inches. All of the adults were inactive. Diggings made two months later likewise yielded all three stages of this scarabæid; the grubs having migrated to a maximum depth of 24 inches in the soil.

**MATING AND PREOVIPOSITION PERIOD.** Overwintering adults issue forth during the early part of May coincident with the appearance of spring foliage, and mating soon follows. Eleven pairs of adults were taken *in copula* on oak and hazel leaves in Anoka County, Minnesota on the night of May 12, 1932. Observations in the field and in the laboratory show that the beetles mate for at least an hour, and that mating may take place during all hours of the night. In the laboratory, where a temperature of about 23° C., was maintained the females were confined in salve boxes containing soil. Under these conditions, the average duration of the preoviposition period for 12 females was 19 days, with extremes of 16 and 20 days.

**OVIPOSITION AND FECUNDITY.** Mated females readily oviposited when isolated in four-ounce salve boxes, or in flower pots, both of which were supplied with moist soil. The length of the oviposition period varied from one to four weeks, most of the eggs being laid during early June. Unlike most members of the



family Scarabæidæ, this species usually deposits its eggs in a mass instead of singly. The eggs are laid several inches below the surface of the soil, and, since the soil adheres to the mass, the mass may be easily passed by as a small clod of earth. Fecundity records kept for 17 females gave an average of 38 eggs for each female (minimum, 28 eggs; maximum, 47 eggs). Only a few adults had a longevity exceeding one month.

**EGG STAGE.** The eggs, when freshly deposited, are pearly-gray in color and elongate-oval in shape. The measurements of a small series were found to average 1.1 mm. in length and .88 mm. in width. As development proceeds, the eggs become chalky white, minutely alutaceous, and assume a more spherical form. Six eggs measured shortly before hatching averaged 1.4 mm. in length and 1.1 mm. in width. Eggs obtained from oviposition cages were isolated within moist black soil in two-ounce salve boxes throughout the oviposition period. These salve boxes were kept at about 32° C., and the length of the egg stage was found to vary from 4 to 16 days, with a mean of 6.8 days for 121 eggs kept under observation. Repeated observations showed that eggs isolated in quite moist soil hatched sooner than those kept in drier soil.

Before hatching the darkened mandibles may be seen clearly through the chorion of the egg. The rupturing of the egg-shell occurs across the back in the region of the thorax and first abdominal segments, and appears to be accomplished by body contractions of the embryo. Following the first small rupture in the egg shell, one grub required only 4 minutes to extricate itself from the shell, but more time was needed to complete the process of hatching by most of the grubs observed. A few hours following hatching the grubs deserted the egg-shell and began to feed on soil.

**LARVAL STAGE.** A large number of small grubs as well as two-year grubs were isolated for rearing in containers supplied with germinating corn, germinating wheat, a combination of vegetable mold and black soil, and grass sod, but all succumbed within a month or two. Instead of attempting to rear the grubs on hazel and oak roots in the laboratory, the writer decided to study the species under field conditions in Anoka County, so periodic dig-

gings were made at the site already described under habitat. As already indicated under hibernation, these diggings show clearly that *S. sericea* has a three-year life cycle.

DESCRIPTION OF LARVA. Mature *Serica sericea* grubs measure approximately 13 mm. in length and 4 mm. in width. The head capsule is largely light brown in color, 1.8 mm. in length and 1.5 mm. at its greatest width; epicranial suture and epicranial arms present but rather indistinct; setation sparse; antennæ five-segmented, third segment almost as long as four and five together; clypeus rectangular, three times as wide as long, sparsely setose; labrum broadly ovate with two anterior emarginations producing a small prominent median lobe, strongly setose on anterior margin.

Apical half of mandibles dark brown or black, scissorial area minutely denticulate; maxillary palpus three-segmented; distal end of galea and lacinia setose; lateral lobes of epipharynx with lateral striæ, setæ on lateral margin increase in length and density distally, three prominent spines in distal sensory area, small setæ present throughout epipharynx except for small area in disk.

Thorax and abdomen white, long brown setæ sparse except on dorsum of tenth abdominal segment, dense; dorsum of first six abdominal segments densely covered with short erect setæ; anal slit obtuse; radula with a conspicuous transverse row of closely set spines, scattered short spines on both sides of mid-line.

Newly hatched grubs of this species are not unlike mature grubs except for their smaller size.

PUPAL STAGE. Although diggings were made periodically for three years in the infested area, living pupæ were not taken. The fact that the first newly emerged adult taken in diggings was on August 30, and, inasmuch as dead pupæ and old pupal casts were taken in diggings made the 12th and 18th of September, it is likely that this species pupates the later half of August. Most of the dead pupæ and old pupal casts were taken at a depth of 12 inches in the soil.

FOOD HABITS AND BEHAVIOR OF ADULT. These crepuscular insects seldom came out for feeding before 8:30 o'clock in the evening. During the daytime they hide beneath the bark of

trees, underneath debris accumulated below shrubs and trees, or in temporary cells within the upper two inches of soil. Adults of *S. sericea* have been taken while feeding on the leaves of oak, hazel, wild plum, aspen, birch, ash, and willow. In the laboratory, the leaves of lilac and box elder were readily consumed by captive beetles. When disturbed the beetles feign death. Advantage of this habit was taken while collecting the beetles. By shaking the limbs of small trees or shrubs into an opened umbrella, large numbers could be collected in a short time.

NOTES ON OTHER SCARABÆIDÆ CAPTURED WITH *S. SERICEA*. While collecting large numbers of *S. sericea* on the night of May 16, 1933, a good series of *Phyllophaga drakei* Kby., and a few specimens of *Phyllophaga anxia* Lec. were captured while feeding on oak and hazel leaves. One night early in that month large numbers of *Phyllophaga tristis* (Fab.) were seen feeding on the leaves of a large oak tree. On the night of May 8, 1934, about 40 adults of the rather uncommon *Phyllophaga prunina* Lec. were taken feeding on oak leaves.

Several species of *Serica* were often found associated with *sericea*, but their numbers were always comparatively small. On May 14, 1932, approximately 30 adults of *S. intermixta* Blatch. were captured while feeding on the leaves of oak, wild plum, birch, and willow. Two adults of this same species were taken on oak and hazel leaves on the night of May 16, 1933, along with 6 adults of *S. atracapilla* (Kby.), and 20 adults of *S. parallela* Csy.





## SOME RAKE-LEGGED MITES OF THE FAMILY CHEYLETIDÆ

BY ARTHUR PAUL JACOT  
APPALACHIAN FOREST EXPERIMENT STATION,  
ASHEVILLE, NORTH CAROLINA

The genus *Cæculus* has been characterized as a very variable species. My studies convince me that although there is a small amount of variation in the number of bristles found in certain places, the species are definite and constant in their many characters. It is necessary however, to study more than one individual of the same stage of development carefully and in a detailed manner. In order to facilitate such study it is advisable to detach the legs and palp of one side (of both if the animal has not been killed in boiling water so as to cause the legs to spread). This is easily done by poking the posterior face of the coxa with a needle. Furthermore, I find that detailed figures are essential, many of the early figures being inadequate to certain reidentification.

As the body is not easily dehydrated, a pin prick (with finest minuten nadeln) to one side of the genital aperture is advisable before placing in absolute alcohol (for balsam mounts). As the bristles do not always dehydrate, it is better to study specimens by direct as well as indirect illumination.

In all my papers, lots without record of collector are understood to be mine.

### Subfamily CÆCULINÆ

Mouth parts fixed, inconspicuous; mandibles small, with uncinate tip; palptarsus inserted on tibia ventroproximally; parasterna (epimera) not joined across thorax; leg segments with five longitudinal rows of bristles; genuals slightly shorter than tibiæ, femora and trochanters distinct, with articulation barely functional, the two segments subequal to genuals in length; mesal and ventral face of legs I each with a row of long spines; adults usually over one millimeter long, brown to black, heavily sclerotized.

Type: *Cæculus* (1).

As a rule nymphs are relatively shorter and broader than the adults, with greater space between mesal ends of parasterna (epimera). The number of bristles along anterior edge of parasterna I as well as the number of spines of legs I may be lower. The number of bristles on genital covers is the most reliable index of stage of development, being one, two, three for the three nymphal stages and six to eight for the adult.

#### Genus CÆCULUS (1)

Dorsal plates distinct, separated by thin often wrinkled skin, to more or less fused; cephalic plate broad enough to cover palps, produced anteriorly to roof over the mouth parts; dorsal bristles very small, usually spatulate.

Type: *Cæculus echinipes* (1).

#### Concerning *Caeculus echinipes* (1)

Three specimens from the Pic du Midi de Bigorre, Pyrenees, France, appear to belong to *C. echinipes* described from the arid hills of Moxente, southern Spain. The original description and figures are so crude as to make positive reidentification except of material from the type locality impossible.

In the genotype the cephalic shield extends posteriad to transverse plane of legs IV. The Florentine *C. echinipes* (5) has a much shorter cephalic plate. In the Pyrenees specimens the plate is of intermediate length. The genotype is figured as having long bristles springing from anterior edge of cephalic plate; Berlese figures them shorter. In my specimens they are still shorter and vary in number, as do the ridges on the plate (none to six, even differing on the two sides). Dufour figured no bristles on dorsum or posterior rim of abdomen (dorsal aspect). Berlese figured none on contour of abdomen but does indicate some of them on the dorsal shields, though they are so smeared over with coloring matter as to be barely distinguishable. I have figured all those discernible on the Pyrenees specimens. These bristles do not seem constant in position at different degrees of inclination of their plate. The transverse plates have three bristles (four if the plate is unusually long). The number on the abdominal plates varies still more (four to six). The skin between the plates is finely wrinkled and capable of much extension (omitted in fig-

ures). It must be said for Dufour that these bristles are very minute and that those of the posterior end of the abdomen vary in position according to the expansion or shrinkage of the abdomen, so that they are not always visible on the dorsal outline.

As to armature of legs I, the coxæ are consistently figured as bearing a short, curved, spatulate bristle on mesal face. Dufour figures the trochanter and femur as fused. Berlese figures these as fused on the left side only. I believe they are normally always distinct but often appear united. Neither of them figure a short spine on proximal end of the tibiæ (mesal face). Dufour figures long bristles on lateral face of legs I. These are really ventral and only visible when the leg is twisted from the normal position.

The figure of Canestrini and Fanzago (4) from the Trentino has all the appearance of being made by direct illumination, so that they miss the edges of the plates, but I cannot reconcile the two rectangular, nested platters figured by them with the system of plates as we know them. Furthermore they figure two bristles each side on posterolateral angles of the cephalic plate!, three tarsal hooks, two long rostral bristles, lateral plate bristles on rim of the inner platter, six on its posterior edge, and six more on posterior edge of outer platter. Of the long anterior bristles one pair may be the pseudostigmatic organs, but the other cannot be reconciled with either the Florentine species or with the specimens before me. Berlese figures five bristles on each lateral plate and two on each transverse.

The species of Karpelles (7) with its one long claw, exposed palps (short cephalic plate), rows of bristles on dorsum, cluster of bristles on posterior edge of abdomen (like *C. spatulifer* (6)), and the barely tapering bristles of legs I, from Fiume, Italy, is still more phenomenal or extremely crude. I do not think it belongs to the above group of forms at all.

Thus I am of the opinion that we have before us four distinct species or subspecies, each confined to its own mountain massif, and I would designate that from the Pyrenees as:

***Cæculus echinipes crosbyi* subsp. nov.**

(Figures 1-8)

*Diagnostic characters:* Bristles of anterior edge of cephalic plate small, inconspicuous; cephalic plate extending posteriad to transverse plane passing

between legs II and III; mesal bristle of coxæ I serrate edged (figure 3); major segment (femur) of palp with two fairly long, ciliate bristles, genual with a longer ciliate bristle (thus differing markedly from the figure given (5, fasc. 73/7); palptibiæ with four bristles: a dorsal and a lateral, barbed, and two smooth mesal, the proximal one with swollen distal end, the proximal pointed; terminal bristle clawlike, strong, with swollen distal end; palptarsus with at least five fine bristles at distal end.

*Description:* Cephalic plate wrinkled, the number of wrinkles not constant or equal on the two sides but about five per side (figure 1), peripheral bristles small, spatulate, ribbed, barbed (figure 2), one to three each side, a pale, more or less colorless area at base, three bristle insertions on each side at widest part; eyes contiguous; median plate roughly rectangular, more or less sculptured with weakly developed vermiculations, with three pairs of insertions: one on anterior edge, another near middle, the other near posterior edge; lateral plate three lobed, extending nearly to eyes, with eight insertions, the distal three nearly in line, the middle three strongly offset, the posterior two on posterior half of posterior lobe, these three groups separated by short pseudofissuræ; posterior plates somewhat oval, with three insertions; these plates, in one specimen are extended mesad and bear a fourth insertion (indicated by dotted lines in figure 1); abdominal plates irregular and inconstant in shape, bearing from four to seven insertions as indicated in figure 1 which is a composite study; other insertions in the thin skin (as indicated in figure 1) vary in position according to degree of extension or shrinkage of body. All these insertions bear small, spatulate, serrate-edged bristles.

Labium, in ventral aspect, with a single pair of insertions; parasterna (epimera) I each with seven slightly clavate bristles, along anterior and mesal edge progressively longer laterad, the lateral as long as width of coxæ; parasterna II each with two insertions near anterior edge; parasterna III narrowly separated from parasterna II, each with three widely spaced insertions near anterior edge; parasterna IV each with three insertions extending diagonally across their plate; genital covers very slender, each with eight insertions on mesal edge; agenital covers angularly semioval, each with three insertions, anal covers slender, each with two insertions; paranal covers crescentic, each with three insertions one of which is on posterior end; posterior end of abdomen emarginate.

Palps as above described. Tarsus less gibbous than figured by Berlese (5, fasc. 73/7), strongly transversely wrinkled, the bristles as in figure 6, depending on orientation and angle of inclination.

Legs I (figure 4, in which, as usual in this genus, the tarsus is foreshortened) with equal ungues (hooks); tarsi I and II with five pairs of short spatulate bristles on dorsal face, four pairs of stout, pointed bristles on ventral face, distal end with a pair of short, pointed bristles on ventral face, another pair, slightly longer on sides, a long, slender, dorsomedian, and a more proximal, spatulate dorsomedian; other segments with five longitudinal rows of bristles: a mesal row of spines, a ventral row of spines, and three dorsal and lateral rows of short, spatulate bristles. Other odd bristles occa-



sionally occur between these rows. The spatulate bristles may be replaced by fine, short, straight bristles; spinelike bristles usually mounted on cylindrical apophyses; tibiae with three subequal, spinelike bristles and a short fine one on mesal face; genuals with three spinelike bristles on mesal face, these bristles progressively longer distad; trochanters and femora each with a long spinelike bristle on mesal face, slightly swollen at distal end; coxæ short-cylindrical, mesal bristle on an apophysis nearly as long as the bristle.

Legs II similar but coxæ longer; trochanters also longer, with three spine-like bristles, the middle one the longest, distal one the shortest; femora short, without spinelike bristles; genuals with two mesal spinelike bristles, the proximal much the longer, ventral face with three medium-long, spinelike bristles, the proximal the shortest; tibiae with mesal and ventral bristles rather short, subequal, five in each row; tarsi quite like tarsi I.

Legs III and IV not specifically differentiated; body of tarsi III (figure 7) and IV with five pairs of spatulate and five pairs of pointed bristles, long dorsodistal bristle much longer, inserted more proximad; genuals, femora and trochanters with spatulate bristles only; coxæ III with three spatulate bristles on lateral face (figure 8), coxæ IV without.

*Cotypes:* Three specimens from under face of stones, Pic du Midi de Bigore, Pyrenes, France; taken July 25, 1932, by Cyrus R. Crosby, slides 331a and -b.

***Cæculus laoshanensis* sp. nov.**

(Figures 15-18)

*Diagnostic characters:* Resembling *C. echinipes crosbyi* but each side of anterior rim of cephalic plate with a single, well-developed bristle inserted on a prominent anteriorly projecting ridge (figure 15); pseudostigmatic organs short, styliform, with slightly clavate head, obliquely truncate (figure 15); posterior plates of dorsal shield continuous, bearing 10-12 bristles; bristles of posterior edge of abdomen broader, veins more branched, teeth broader and smaller; only five bristles on parasterna I; parasterna III with lateral bristle absent or not discernible; agenital plates with but two bristles each; coxæ of legs I with two spatulate bristles on mesal face (figure 16); mesal spines of trochanter and femur equally developed; proximal bristle of genuals very small (figure 16); claws of legs I and II very unequal, of III and IV equal (figure 17).

*Description:* Rather than describe the form in detail, only the points of minor difference with *C. echinipes crosbyi* will be given. The bristle ridges of the cephalic plate give it a horned appearance; lateral bristles of hood inserted more posteriad, slightly posteriad of greatest width of hood; row of three posterior bristles more closely spaced, more distant from eyes; lateral plates with only seven bristles arranged 2:2:3 (with the colon standing for the pseudoforamen); bristles of dorsal shield and abdomen larger; mesal bristles of parasterna III and IV close to each other; entire animal broader; agenital and adanal plates smaller.

*Nymphs* I (figure 18) and II (with 1 and 3 bristles to each genital cover, respectively) with four bristles on parasterna I; tarsal claws as in adults except that legs III and IV have the outer nail (corresponding to the small nail of legs I and II) slightly weaker than the other; trochanters I with mesal spine short, clavate (figure 18); genuals I with but one long spine (and a short one).

*Cotypes*: Three adults, five nymphs from grass clump, dry, shady locality, Bai Djiou Shui Miao, Lao Shan Mts., Shantung, China; taken June 15, 1928, slides 2815 Caec. 1 and -2.

*Cæculus sinensis* sp. nov.

(Figures 23-28, 30-31)

*Diagnostic characters*: Bristles of dorsal aspect spatulate; dorsal plates considerably fused and indistinct, forming a dorsal shield; cephalic plate with anterior bristles minute, inserted on dorsal face of plate in the furrow which causes the emargination of the edge (figure 23); another pair of minute bristles on cephalic plate, inserted on transverse plane passing just posterior of the lateral bulge of cephalic plate; a bristle inserted anteromesad of eyes, distant from eyes slightly more than diameter of one of them (figure 23); area of median plate with three pairs of bristles, laterad of these pairs near lateral margin of dorsal shield a bristle (totaling three along each side); posterior edge of dorsal shield (area of transverse plates) with five bristles; posterior edge of abdomen with five bristles; parasterna I with six bristles inserted along anterior and mesal edges; genital covers with six bristles; labium (hypostome) with two pairs of bristles, their insertions quite evident in ventral aspects, a marked fenestration between apices of mandibles and maxillæ; pseudostigmatic organs slender, barely clavate.

*Description*: Cephalic plate, compared with *C. echinipes crosbyi* short, broad, with a well defined, broad emargination, forming a broad median lobe and two angular lateral lobes which are the apices of diverging ridges (figure 23). This species differs from several of the European (the *C. echinipes* group) by having the anterior bristles inserted in the groove instead of on the apex of the lateral lobes or ridges; occasionally two bristles may be seen closely crowded together in one groove, and one in the other; median plate only faintly sculptured; anterior pair of bristles of median plate more approximate than those of the other two pairs; an individual has the posterior bristle of the lateral plates replaced by two; bristles about posterior end of abdomen vary in exact position according to degree of inflation or wrinkling of abdomen, there are two pairs at lateral angles: one dorsal and one ventral, the ventral one being figured in the lower half of figure 23.

The pattern of the ventral aspect of the mouthparts with its four insertions and two fenestrations (forming six symmetrical light spots) is very characteristic (see also figure 29). The upper part of the camerostome projects as a distinct labrum with two or three median denticles (figure 31) and is overarched by the cephalic hood (plate). Parasterna with mesal edges

rather remote; parasterna II with three bristles fairly close to anterior edge; parasterna III with one bristle near center of anterior edge and one at mesal end; parasterna IV with three bristles along center of plate and one at posteromesal corner; minute bristles of ventral skin omitted.

Legs I and II with unequal ungues, the mesal being less than half length of lateral (figures 21 and 22), mounted on a distinct T-shaped unguitractor plate which articulates between two apophyses of the tarsal wall (figures 21 and 22, where these apophyses are black); tarsi I with only four bristles in longitudinal rows, no long dorsomedian bristle (figure 24); tibiae with three bluntly pointed spines on mesal face, the proximal being half length of the others, a medium long and a short bristle between the two longitudinal rows of spines (figure 24); genuals with two mesal spines, the proximal one clavate, half the length of the other; femora with one long, mesal, slightly clavate spine. Trochanters as femora; coxae with two short, clavate mesal bristles, the distal one the longer (figure 24); spines of ventral face similar to mesal face but no spine on femora or coxae.

Legs II similar but spines not so long, not developed on trochanters and femora, though trochanter has a rather long, clavate bristle on ventral face; genuals with a fairly long, clavate bristle on ventral and on mesal face.

Legs III and IV with equal claws. Tarsi with long dorsomedian bristle and four to five bristles in longitudinal rows. Other segments not conspicuously differentiated.

*Nymphs*: In dorsal aspect the nymphs are similar to the adults, but the body is shorter and broader. All nymphs have four bristles on each parasterna I (figures 30 and 31). The mesal bristle of parasterna II is inserted on juncture of parasterna I and II. In nymphs I parasterna IV are relatively much smaller than the other three and they seem to have one or two bristles less. In figure 30, the lower parasternum I is abnormal in that it has an extra bristle. Each genital cover has six bristles in nymphs III, three in nymphs II and one in nymphs I. The spines of legs I are similar in all nymphal stages except in the case of the genual, where the proximal spine seems more robust and longer in nymphs III than in some adults and is absent in nymphs I.

*Cotypes*: Three adults, five nymphs, from leaf mould, the repant *Selaginella mongolica*, and the fuzzy, dried up leaves of *Boea hygrometrica* from ravine of Chaoyang An, hills west of Peking, China; taken September 7, 9 and 19, 1921; slides 21124, 21126, 21171a.

***Cæculus sinensis taishanicus subsp. nov.***

(Figures 19-22, 29)

Differs from the species in that the cephalic plate has the anterior edge much more deeply emarginate, leaving a much narrower median lobe (figure 19); anterior bristles larger, projecting well beyond edge of plate, inserted

on conspicuous nubbins; pseudostigmatic organs stouter, not clavate, coarsely burred, blunt (figure 19); lateral bristles of cephalic plate larger, inserted nearer lateral edge of plate; in the one specimen there are but two bristles on posterior edge of abdomen though this is undoubtedly due to injury.

Parasterna I each with seven bristles; parasterna II each with four bristles, the extra one being on the mesal end; I was unable to discern bristles on mesal end of parasterna III and IV because of dense black substance on this area; for bristles of ventral skin see figure 19; all bristles of ventral aspect longer than in the species.

Legs similar to the species but the spines are longer and sharper, the only clavate spine being that of coxæ I, which immediately differentiates the two forms (figures 20 and 24). Moreover the two spines of genuals I are subequal.

This is a more specialized form of the species.

*Nymphs*: What I take to be nymph III has six bristles to each parasterna I and (very distinctly) four bristles to each genital cover, thus being radically different from the species (figures 29, where the lower parasternum II is abnormal in possessing an extra bristle).

*Cotypes*: One adult, five nymphs, from heavy, green, foliose lichens on boulders near Erhu Miao, Taishan, Shantung, China; taken July 19 and 25, 1923, slides 2332n1 and 2345.

It may seem remarkable to find the species of the hills of western Shantung closely related to that of the Peking hills while the species of east Shantung is entirely different. This however is in harmony with distributional data of other phylla and warrants the inference that Korea has a species closely related to that of eastern Shantung. Later researches may require placing *C. sinensis* in another genus. The number of dorsal bristles and the agenital plates are much reduced.

In retrospect, the armature of legs I serves as a remarkably constant and easily observed specific (and subspecific) character, but one must be sure to view the leg exactly dorsoventrally or the ventral spines will appear subimposed against the mesal. The development of the cephalic plate and number, position, and development of its bristles are also of great value. The character of the body bristles also differs between species (compare figures 25 to 26 with 2, 3 and 5, and with 11). The pseudostigmata are anterodorsad of the palp insertions and therefore more approximate. The organs are very characteristic of the species and differ widely between species.



*PROCAECULUS gen. nov.*

Cephalic plate so poorly developed that the pseudostigmata and even the rostrum are visible in dorsal aspect.

Type: *Procaeculus bryani* sp. nov.

*Procæculus bryani sp. nov.*

(Figures 9-14)

*Diagnostic characters:* Anterior bristles long, clavate, distal end curved mesad (figure 9); pseudostigmatic organs fairly long, abruptly clavate, the head studded with minute warts (figure 13); bristles of posterior edge of dorsal shield and abdomen, smooth, spoon-shaped (figures 9 and 11); coxæ I with a small, weakly clavate bristle on mesal face; trochanters and femora appear fused in the holotype, the trochanteral bristle shorter, curved, pointed; genuals with two spines and a minute, proximal bristle; claws equal (figure 10); palps with a ciliate, and a clavate bristle (figure 14).

*Description:* The holotype is too dense to make a detailed description possible.

*Holotype:* An adult (?) from Peale Island, Wake Island, Western end of the Hawaiian Island group; taken July 21, 1923 by E. H. Bryan on the Tanager Expedition, slide BBMo6T.

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15. VITZTHUM, HERMANN, 1933 (Dec. 15). Die Larvenform der Gattung *Cæculus* Dufour, Zool. Anz., vol. 105, pp. 85-92, 5 figs.

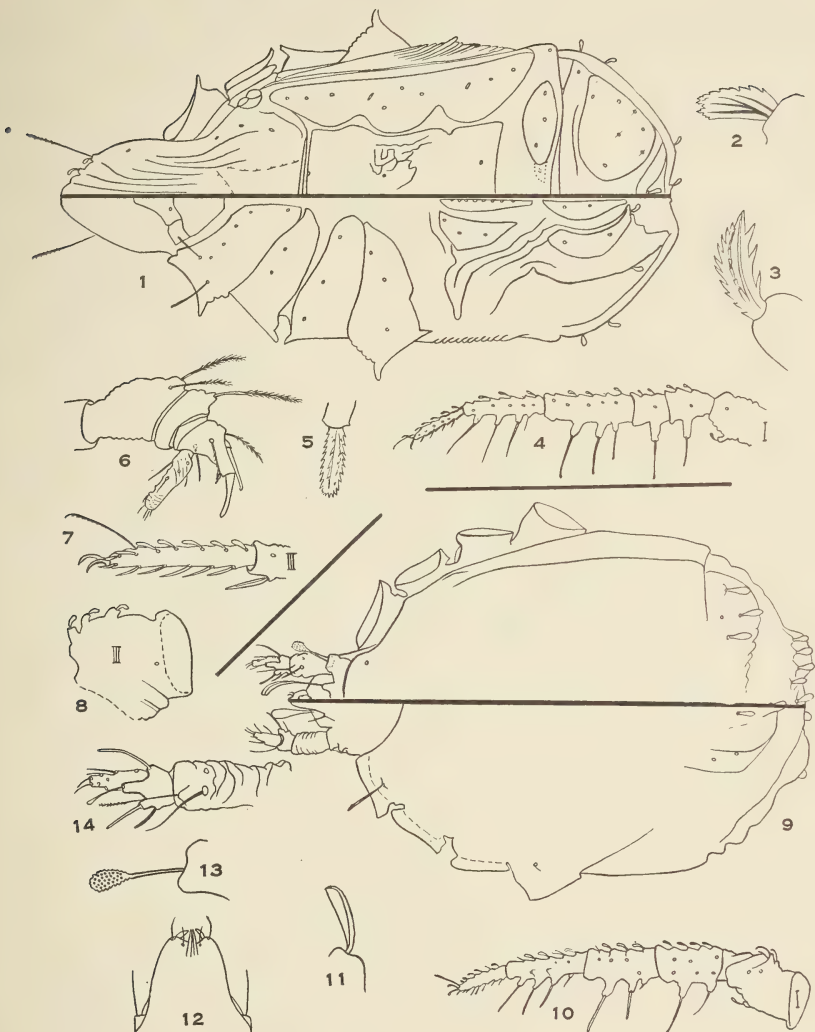
## PLATE I

***Cæculus echinipes crosbyi subsp. nov.*, adult**

- Figure 1. Dorso/ventral aspects, legs and mouthparts omitted; ratio  $\times 60$ .  
 Figure 2. Bristle from edge of cephalic plate; ratio  $\times 440$ .  
 Figure 3. Bristle from coxa of legs I; ratio  $\times 440$ .  
 Figure 4. Legs I, dorsal aspect; ratio  $\times 40$ .  
 Figure 5. Bristle of femur of legs II; ratio  $\times 200$ .  
 Figure 6. Palp, lateral aspect; ratio  $\times 120$ .  
 Figure 7. Tarsi III; ratio  $\times 75$ .  
 Figure 8. Coxal trochanter III; ratio  $\times 100$ .

***Procæculus bryani gen. et sp. nov.*, nymph III**

- Figure 9. Dorso/ventral aspects, legs omitted; ratio  $\times 75$ .  
 Figure 10. Legs I, dorsal aspect; ratio  $\times 40$ .  
 Figure 11. Bristle from coxa of legs I; ratio  $\times 440$ .  
 Figure 12. Mouthparts, ventral aspect; ratio  $\times 200$ .  
 Figure 13. Pseudostigmatic organs, dorsal aspect; ratio  $\times 150$ .  
 Figure 14. Palp, dorsal aspect; ratio  $\times 150$ .



CÆCULINÆ

## PLATE II

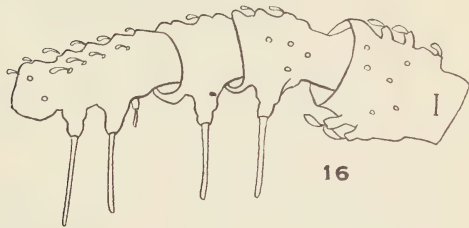
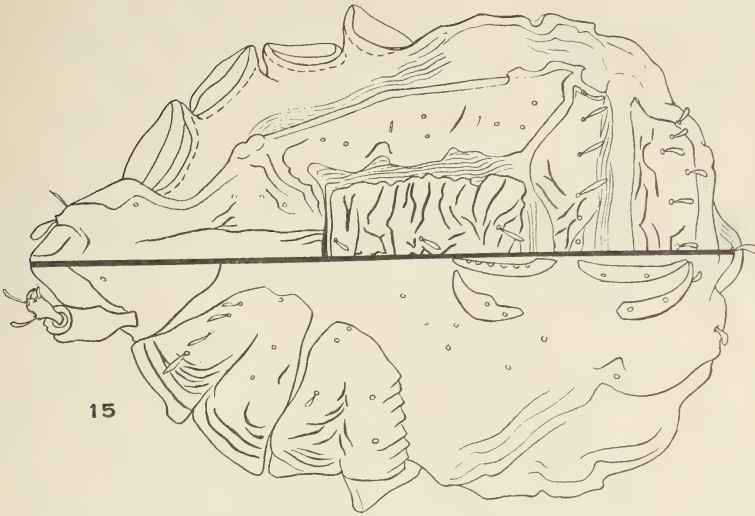
*Cæculus loashanensis* *sp. nov.*, adult

- Figure 15. Dorso/ventral aspects, legs omitted; ratio  $\times 60$ .  
Figure 16. Trochanter to genual of legs I; ratio  $\times 60$ .  
Figure 17. Distal end of tarsi III or IV; ratio  $\times 60$ .

## NYMPH I

- Figure 18. Ventral aspect, legs II to IV omitted; ratio  $\times 60$ .





CÆCULINÆ

## PLATE III

***Cæculus sinensis taishanicus subsp. nov.*, adult**

- Figure 19. Dorso/ventral aspects, mouthparts and legs omitted; ratio  $\times 60$ .  
Figure 20. Legs I, somewhat foreshortened; ratio  $\times 40$ .  
Figure 21. Claws of tarsi I, mesal aspect; ratio  $\times 200$ .  
Figure 22. Claws of tarsi II, ventral aspect; ratio  $\times 200$ .

***Cæculus sinensis sp. nov.*, adult**

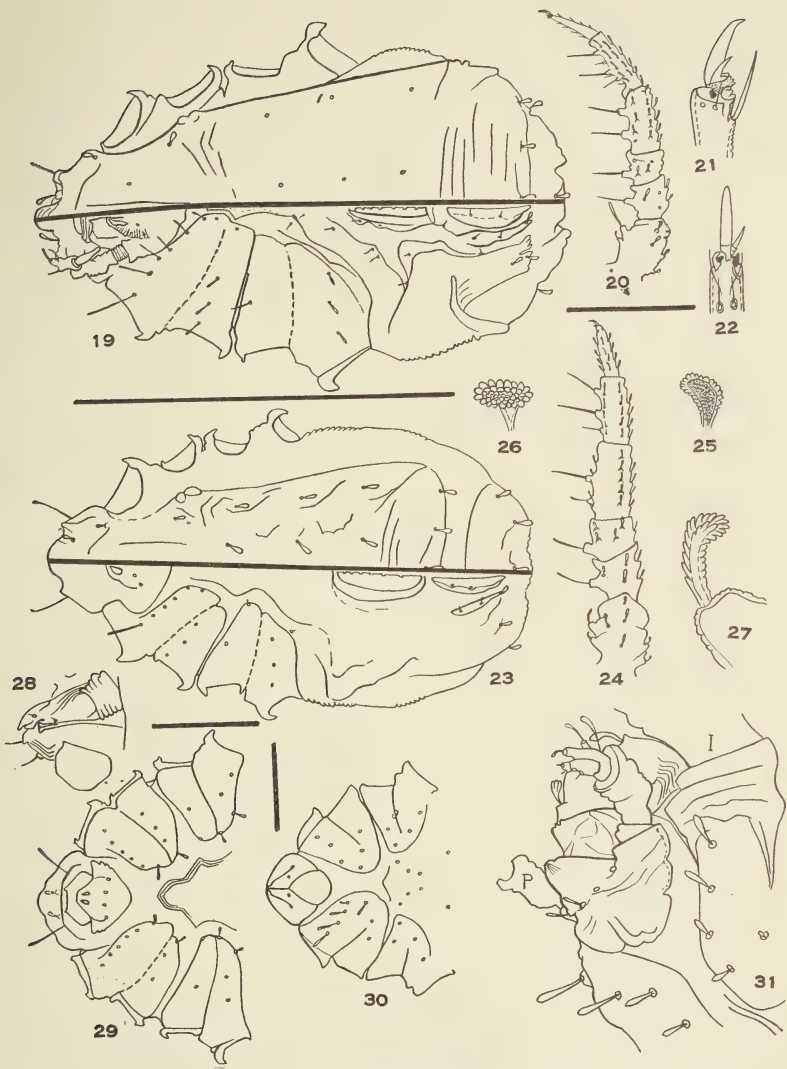
- Figure 23. Dorso/ventral aspects, mouthparts, legs, and minute bristles of venter omitted; ratio  $\times 75$ .  
Figure 24. Legs I, foreshortened; ratio  $\times 60$ .  
Figure 25. Marginal bristle of cephalic plate, oblique aspect; ratio  $\times 440$ .  
Figure 26. Marginal bristle of abdomen, end view; ratio  $\times 440$ .  
Figure 27. Mesal bristle of coxæ I; ratio  $\times 440$ .  
Figure 28. Mouthparts, ventral aspect, showing maxillæ and mandibles above, removed on lower half of figure to show side of camerostome with its two bristles, and attachment rim of palp; ratio  $\times 100$ .

***Cæculus sinensis taishanicus subsp. nov.*, nymph III**

- Figure 29. Ventral aspect of cephaloprothorax, mouthparts and legs omitted; ratio  $\times 60$ .

***Cæculus sinensis subsp. nov.*, nymph II**

- Figure 30. Ventral aspect of cephaloprothorax, mouthparts and legs omitted; ratio  $\times 60$ .  
Figure 31. Mouthparts and parasterna I, ventrolateral aspect; ratio  $\times 150$ .



CÆCULINÆ





## STUDIES ON LEIODIDÆ

BY MELVILLE H. HATCH

Some years ago I published a table of the described genera of this family (Hatch, Jour. N. Y. Ent. Soc. XXXVII, 1929, p. 1-6). Since then Portevin (Hist. Nat. Col. France I, 1929, p. 543) has pointed out that *Xanthosphæra* Fairm. is probably founded on a composite specimen and is to be regarded as a synonym of *Triarthron* and *Cyrtusa*. I myself have in press the description of a remarkable blind genus, *Typhlroleiodes*, from northwestern Oregon. Except for the absence of eyes, it runs to *Hydnobius*, being distinguished therefrom by its truncate labrum.<sup>1</sup> In order not to confound *Typhlroleiodes* with the totally distinct *Scotycryptini*, the first line of the key will have to be rephrased as follows:

“A<sup>1</sup>. With or without eyes; tarsi three to five segmented, if without eyes (*Typhlroleiodes*) the tarsi five segmented; abdomen five or six segmented.”

*Hydnobius* Schm.

In the *matthewsi*-section of this genus, with the labrum feebly emarginate, Mr. W. J. Brown has recently described two species: *simulator* from British Columbia (Can. LXIV, 1932, p. 6) and *validus* from Quebec (l.c., p. 202).

The following key to the males of the *substriatus*-section of the genus, with the labrum deeply bilobed, will serve to introduce three new species from western Washington and render unnecessary comparative statements under the several species. I have had before me of the previously described species only *substriatus* LeC., represented by specimens from Alberta and Washington, and *pumilus* LeC. (*latidens* LeC.) represented by specimens from

<sup>1</sup> “Labrum” should replace “clypeus” under *Hydnobius* and *Dietta* on page 1 of my key. Two other corrections in my key may here be noted: (1) In the Leiodini (p. 1) the anterior are *with* spines and in the Agathidiini (p. 3) the anterior tibiae are usually *without* spines; (2) *Pseudocolenis* was described by Reitter and not by Portevin. *Typhlroleiodes* was described in Pan. P. Ent. XI. 1935. p. 116.

Quebec kindly presented to me by Mr. W. J. Brown. Despite this, I feel that the characters of my new species are of such moment as to render their description justified. For bibliography see Hatch, Col. Cat. 105, 1929, p. 11-12.

Key to Males of *substriatus*-section of *Hydnobius* Schm.

1. Metafemora somewhat broader than in female, but not dentate, denticulate, or serrate.
2. Elytra eight-striate, the intervals alternately finely closely and coarsely distantly punctate; metatibia arcuate; length 2-2.5 mm.; Colorado, British Columbia ..... *obtusus* LeC.
- 2'. Elytra with eighteen nearly equal rows of punctures; metatibia straight; length 2.5 mm.; Alaska ..... *luggeri* Hatch.
- 1'. Metafemora dentate, denticulate, or serrate along lower margin.
3. Metafemora with a well developed tooth on lower margin towards apex.
4. Elytra confusedly punctate; metafemoral tooth longer than broad, obliquely truncate at apex; metatibia straight; length 3.5 mm.; British Columbia, Oregon, California, Colorado ..... *longulus* LeC.
- 4'. Elytra substriately punctate; length 1.5-2.5 mm.
5. Punctures of elytral intervals subequal to those of the striæ; metatibiæ straight or nearly so.
6. Metafemoral tooth subspinose, as long or slightly longer than broad, the margin of the femora proximad to the tooth finely serrulate; elytral intervals not transversely wrinkled; length 2-2.5 mm.; Nova Scotia, New York, Michigan, Canada, Colorado, Alberta, Washington ..... *substriatus* LeC.
- 6'. Metafemoral tooth triangular.
7. Metafemoral tooth shorter, obliquely truncate at apex; length 2 mm.; New York ..... *laticeps* Notman.
- 7'. Metafemoral tooth longer, acute; elytral intervals somewhat transversely wrinkled; length 1.5-2 mm.; Quebec, Colorado, California ..... *pumilus* LeC. (*latidens* LeC.).
- 5'. Punctures of elytral intervals considerably fainter than those of the striæ, the intervals faintly transversely wrinkled; metafemoral tooth triangular, acute; metatibia strongly arcuate at base; length 1.9 mm.; western Washington ..... *kiseri* sp. nov.
- 3'. Metafemora without tooth on lower margin towards apex; metatibia straight.
8. Metafemora broadly obtusely lobed along lower margin towards apex, the edge of the femur just before the apex obliquely truncate, the margin proximad to the lobe finely serrulate; elytral punctation substriate, the punctures of the intervals nearly equal to those of the striæ, the intervals feebly transversely wrinkled; length 3 mm.; western Washington ..... *lobatus* sp. nov.
- 8'. Metafemora neither lobed or dentate, the lower margin set with four or five minute denticles; elytral punctation substriate, the punctures of

the intervals feebler, the intervals strongly regularly transversely strigose; head and pronotum somewhat less regularly transversely wrinkled;<sup>2</sup> length 1.8–2 mm.; western Washington and British Columbia ..... *femoratus* sp. nov.

***Hydnobius kiseri* sp. nov.**

Male: length 1.9 mm.; pale straw colored; labrum deeply bilobed; head and pronotum shining, finely sparsely punctate, the head more so than the pronotum; pronotum subequal in width to elytra, about two-thirds as long as broad, the apex more than three-fourths as wide as the base, the sides arcuate and finely margined, the basal angles obtuse, the base margined; elytra shining, with distinct sutural stria extending in front of basal third; the elytral punctures moderately impressed, in longitudinal series, with the punctures of the intervals rather feeble, the intervals with faint obliquely transverse wrinkles; basal segments of front and middle tarsi not or very feebly dilated; metafemur with a prominent triangular tooth on lower margin towards apex, the outer surface of the femur coarsely but not densely punctate; metatibia strongly arcuate at basal two-fifths.

Type male: Harper, Wash. (vii-4-1931. R. W. Kiser).

***Hydnobius lobatus* sp. nov.**

Male: length 3 mm.; rufo-testaceous; labrum deeply bilobed; head and pronotum shining, punctate, the head more finely so than the pronotum; pronotum subequal in width to elytra, five-eighths as long as broad, the apex about nine-tenths as broad as base, the sides arcuate and finely margined, the basal angles broadly rounded, the base margined, somewhat more broadly so towards the sides; elytra shining, with impressed sutural stria extending in front of middle and continued thence to base by one of the numerous rows of elytral punctures; elytral punctures distinct, arranged in feebly impressed longitudinal series, those of the intervals nearly as large but not quite as regularly arranged, the intervals with occasional faint transverse wrinkles; basal segments of front and middle tarsi scarcely dilated; metafemur with an evident low obtuse rounded lobe at that portion of the lower margin occupied by a tooth in *kiseri* and other species, the edge of the femur between the apex of the femur and the tip of the lobe obliquely truncate, the margin of the femur proximad to the lobe finely serrulate, the outer surface of the femur punctate, sparsely pubescent; metatibia straight.

Type: Manchester, Wash. (IV-22-1934), collected by Miss Harriet White.

<sup>2</sup> With somewhat similarly transversely strigose elytral intervals is *arizonensis* Horn, known only from the female. In this species, however, only the alternate elytral intervals are punctate.

**Hydnobius femoratus** sp. nov.

Length 1.8–2 mm.; rufous, the antennal club somewhat darker; labrum deeply bilobed; head and pronotum shining, finely punctate, the punctures joined by numerous more or less discontinuous transverse strigæ; pronotum at basal third a trifle wider than elytra, three-fifths as long as wide, apex three-fifths as wide as base, the sides strongly arcuate and finely margined, the hind angles obtusely rounded, the base very broadly margined at sides, narrowly margined at middle; elytra shining, with sutural stria nearly entire, towards the base punctate and feebly impressed; elytral punctures in feebly impressed longitudinal series, the intervals more finely but regularly punctate and regularly transversely strigose; basal segments of front and middle tarsi evidently dilated in male, simple in female; metafemora simple in female, in male with the lower margin set with a series of four or five denticles; metatibia straight.

Type male: Seattle, Wash. (V-28-1929. M. H. Hatch). Allotype female: same data VI-3-1929. Two paratype males: same data: V-26-1929 and VI-20-1929. One paratype female; same data: VI-7-1929. One paratype female: Tod's Inlet, B. C. (Buschart Gardens, V-30-1930. M. H. Hatch). The Seattle specimens were taken sweeping towards sundown in a lightly wooded area that has since been made into a playfield.

*Leiodes* Latr. (*Anisotoma* Schm., Horn, Leng)

Of the species listed by me (Hatch, Col. Cat. 105, 1929, p. 36-37) under *Leiodes* s. str., *conferta* LeC., *paludicola* Cr., and *strigata* LeC. can probably be placed in the subgenus *Pseudohydnobius* Ganglb., in which the punctures of the striae and intervals are subequal. I now doubt, however, the correctness of my assigning (l. c., p. 38) the species of the *obsoleta*-group (with mesosternum vertical between the coxae) to the subgenus *Oreosphaerula* Ganglb., which is characterized by a strongly carinate mesosternum, the carination suddenly declivous in front of the tarsi.

*Leiodes horni* Hatch (*humeralis* Horn) and *merkeliana* Horn. —*Merkeliana* is, in reality, far more closely related to *horni* than to *valida* Horn, as implied in the original description. In fact, it is possible that it is simply a phase of *horni* with very strongly developed or exaggerated male secondary sexual characters. I have specimens of both from Washington.



*L. valida* Horn and *L. assimilis* LeC. are similar in that the males of both have the lower outer margin of the metafemur crenulate or serrulate. In *valida* the femur is described as subangulately dilated or subdentate at the middle, the crenulation confined to the portion between the angulation and the base. The male metafemur in *assimilis* was described as unmodified except for the serrulation, but a short series of males from Thunder River, Quebec, kindly presented to me by Mr. W. J. Brown, as well as a single male collected by myself at the Straits of Mackinaw, Michigan, show that the apical condyle of the ventral surface varies from obtusely rounded to prominently subdentately produced; the length of the animal, moreover, may be as low as 2.7 mm. In *serripes* sp. nov., described below, the male metafemur is distinctly subangulately dilated at about the basal two-fifths, the margin thence to the condyle finely denticulo-serrate, the condyle broadly arcuately and somewhat prominently lobate.

***Leiodes* (s. str.) *serripes* sp. nov.**

Length 2.6–3.5 mm. Castaneous, the head, pronotum, and antennal club somewhat darker to nearly piceous; head shining, finely densely punctate with a transverse series of four larger punctures; pronotum shining, somewhat less finely and densely punctate, with a short series of coarser punctures along the base just within the broadly rounded hind angles, four-sevenths as long as broad, widest in front of the hind angles, the apex about two-thirds as wide as the base, the sides strongly and the base broadly arcuate, the sides and apex finely beaded; elytra with striæ coarsely punctate, feebly impressed except the sutural stria which is strongly impressed, the intervals finely punctulate, the alternate intervals with distant larger punctures; mesosternum oblique between the coxæ, evidently carinate, the carina not declivous in front of the coxæ; metasternum and abdominal sternites alutaceous; basal segments of pro- and mesotarsi somewhat dilated in male, narrow in female; metafemur obliquely strigulose, coarsely and sparsely punctate, simple in female, in male distinctly subangulately dilated at about the basal two-fifths, the margin thence to the condyle finely denticulo-serrate, the condyle broadly arcuately and somewhat prominently lobate; metatibia slender and nearly straight in female, strongly arcuate towards apex in male.

Type male: Seattle, Wash. (V-30-1929. M. H. Hatch). Allotype female: same data V-28-1929. Paratypes males: Seattle, Wash. 5-16-13 and Mt. Rainier, Wash. (Green Water R., June 6, 1930, M. H. Hatch and Paradise Park, Aug. 8, 1930, M. H. Hatch). Paratype females: same data as type VI-2-1928, and

Seattle, Wash. (5-16-13), with which are associated two other females from Seattle (July 5, 1928 and 5-16-13). The type and allotype were taken sweeping in the same locality as the *Hydnobius femoratus* described above. The 3.5 mm. specimen is a male from Paradise Park with the apex of the metatibia unusually strongly arcuate and the pronotum nearly concolorous with the elytra; I hesitate for the present to regard it as other than an individual variant.

*Anisotoma* Ill. (*Liodes* Lacord., Horn, Leng, etc.)

***Anisotoma interstitialis* sp. nov.**

Length 3 mm.; oval; testaceous, the antennæ, the front of the head on either side towards the eyes, the disc of the pronotum and a large medio-sutural spot on either elytron castaneous; head and pronotum shining, finely punctate; pronotum four-ninths as long as wide, widest at base, the apex five-ninths as wide as base, the sides arcuately convergent from the narrowly rounded basal to the broadly rounded apical angles, sides and apex finely beaded, base broadly arcuate at middle and oblique at extreme sides towards the angles; elytra at base a little wider than pronotum, widest between basal fourth and third, with sutural stria impressed at apical half, the other striæ represented by about seven longitudinal bands of coarse punctures with narrower bands of fine punctures in between; mesosternum not carinate; metasternum and abdominal sternites alutaceous, punctate.

Type and paratype: Seattle, Wash.

Runs to *geminata* Horn in Horn's Key (Trans. Am. Ent. Soc. VIII, 1880, p. 297) from which it is distinguished by its paler color (*geminata* is black), the broader bands of coarse punctures and finely punctate intervals (these impunctate in *geminata*).

*Agathidium* Ill.

My attempts to define the subgenera of this genus (Jour. N. Y. Ent. Soc. XXXVII, 1929, p. 4) and to allocate the Nearctic species among them (Col. Cat. 105, 1929, p. 71-72, 81) may be much improved on. First, I give a translation of the key to the three principal subgenera as given in Schaufuss, Calwer's Kaferbuch ed. 6, I, 1909, p. 289, substituting *Cyphoceble* for *Saccoceble* as explained by me in Col. Cat. 105, 1929, p. 78.

1. Elytra with oblique humeral angles. Mesosternum carinate almost to the apex. Body completely contractile. Mandible of male simple. Female tarsi 5-4-4 ..... subg. *Agathidium* s.str.

- Elytra with humeral angles obtusely or rectangularly rounded. Mesosternum briefly or not carinate. Body incompletely contractile. Male frequently with the left mandible enlarged or horned. Female tarsi 5-4-4 or 4-4-4.
- 2. Head narrowed directly behind the eyes or with only a short tempora ..... subg. *Neoceble* Gozis.
- Head behind the eyes with well developed tempora half as long as the eyes. Female tarsi 5-4-4 ..... subg. *Cyphocele* Thoms.

Applying these characters to the species set forth in Fall's recent and most excellent review of the Nearctic species (Ent. Am. XIV, 1934, p. 99-131), it is possible to allocate our species as follows.

In *Agathidium* s. str.: *oniscoides* Beauv., *rubellum* Fall, *compressidens* Fall, *exiguum* Melsh., *dentigerum* Horn, *alutaceum* Fall, *californicum* Horn, *depressum* Fall, *jasperanum* Fall, *dubitans* Fall, *revolvens* LeC., *cavisternum* Fall, *virile* Fall, *conjunctum* Brown, *omissum* Fall.

In the subgenus *Neoceble* Gozis:<sup>3</sup> *sexstriatum* Horn, *bistriatum* Horn, *estriatum* Horn, *parvulum* LeC., *parile* Fall, *rusticum* Fall, *lactum* Fall, *contiguum* Fall, *athabascanum* Fall, *alticola* Fall, *columbianum* Fall, *rotundulum* Mann., *brevisternum* Fall, *atronitens* Fall, *repentinum* Horn, *politium* LeC., *maculosum* Brown and var. *franciscanum* Brown, *pulchrum* LeC., *picipes* Fall, *difforme* LeC. (*canadensis* Brown).

In the subgenus *Cyphocele* Thoms.: *angulare* Mann., *concinnum* Mann., *municeps* Fall, Pan-P. Ent. X, 1934, p. 171 (*temporale* Fall nec Sahlb.), *assimile* Fall, *mollinum* Fall.

I find I have specimens of two undescribed species of the subgenus *Neoceble*.

***Agathidium (Neoceble) kincaidi* sp. nov.**

Female: length (contracted) 1.3 mm.; globose, strongly convex and contractile; dark piceous brown, the feet and antennæ a little paler, the margins of the pronotum and elytra translucent; head, pronotum, and elytra shining, alutaceous, finely and shallowly punctate, the elytra without a scutellar stria; pronotum about three-fifths as long as wide, the side margin strongly arcuate, the hind angles broadly rounded; female tarsi 4-4-4.

Type and paratype: Loveland, Wash. (April 8, 1913). Collected by Trevor Kincaid.

<sup>3</sup> Dr. Fall, by correspondence, kindly confirms the absence of a postocular tempora in those species in which the feature is not mentioned in his review.

From the other species without scutellar stria, *kincaidi* is distinguished from *maculosum* Brown by its uniform coloration and smaller size and from *rotundulum* Mann. and *brevisternum* Fall by its feebly punctate dorsal surface, impunctate in these species).

*Agathidium (Neoceleb) varipunctatum* sp. nov.

Length 1.8 mm.; oval; castaneous; head shining, finely punctate, without post-ocular tempora, transversely impressed across vertex, the left mandible with (male) or without (female) a long tooth directed obliquely caudad; pronotum shining, finely punctulate, less than half as long as broad, the side margins suboblique in front of the obtusely rounded hind angles; elytra shining, with well impressed sutural stria in apical half, the surface with intermixed coarser and finer punctures, some of the coarser punctures feebly serially arranged; metasternum and abdominal sternites alutaceous, punctate; tarsi of female 5-4-4.

Type male: Seattle, Wash. (IV-13-1931, M. H. Hatch). Allotype female: same data II-18-1934. Paratype female: same data 1933.

This species runs to the *pulchrum-picipes-difforme*-group of Fall's key (i.e., p. 104-105) from all of which, as well as from the other species without postocular tempora and with a sexually dimorphic left mandible, it appears to differ by the intermixed coarse and fine punctures of the elytra. From *pulchrum*, moreover, it differs by the absence of maculation, from *picipes* by the castaneous legs, and from *difforme* by the absence of a darker scutellar spot.

Scotocryptini

The biological relationships of this interesting group have recently been reviewed by Dr. George Salt (Trans. Ent. Soc. London 77 (2), 1929, p. 450-452, pl. XXVI, fig. e, f, g.), who has added original observations in connection with a couple of the species. Therein and in Col. Cat. 105, 1929, p. 83, I express the opinion that *Scotocryptus obscurus* Sharp is synonymous with *S. meliponae* Girard. I have now before me, through the kindness of the authorities of the British Museum, a cotype of *obscurus* Sharp from Bahia, Brazil. It reveals a species closely related to the species I identified as *meliponae* Girard in Dr.



Salt's paper. The antennal structure is the same,<sup>4</sup> but the color is piceous black, not dark rufous as Dr. Salt's specimen; the length is about a millimeter less, about 3.1 mm., and the elytra are, perhaps, a trifle more elongate. The species may well be retained as distinct until more specimens of these interesting beetles have been collected and reported upon.

I take the present opportunity to record *Parabystus inquilinus* Matth. from the nest of the bee *Trigona* sp. at Guapiles, Costa Rica. My specimen is one of three collected by Mr. Ferd. Neverman and sent to me through the kindness of Dr. Fritz van Emden. The species is previously known from Cerro Zunil, Guatemala, and Palpa, Mexico.

*Note.*—All type material of new species described in the present paper is deposited in the collection of the author.

<sup>4</sup> In my descriptions of *meliponae* and *melitophilus* in Dr. Salt's paper read "seventh" and "sixth" for "eighth" and "seventh" antennal segments. The error was mine and not Dr. Salt's!





## AERONAUTIC SPIDERS WITH A DESCRIPTION OF A NEW SPECIES

BY C. R. CROSBY AND S. C. BISHOP

The earliest account of aeronautic spiders I have been able to find was published by Martin Lister in 1678 in his *Historiæ animalium Angliæ*, page 8. He writes:

“Sed quod omnem fidem superat; & de quo omnino nulla mentio apud antiquos aut recentiores est, Araneolos, aut mediæ certè ætatis & magnitudinis, nam adultos in aëre me nunquam observâsse memini, fili auxilio se committere leni auræ, ascensúmque; in aërem pérque; summas nubes moliri: Illud certè verissimum est, eas longè extra conspectum meum evectos fuisse, etiamsi supra celsissimam Turrem aliquoties de industria contemplerer.

“Ad Octobrem verò mensem hanc exercitationem maximè frequentant; quamvis per totum annum, etiam mediâ brumâ, si quando per id tempus sol clarè splendescat, & tranquillus aër sit, hujus quidem ejaculationis non paucos effectus per agros pérque; sepes non rarè animadverti.”

In America the earliest recorded observations seem to have been made about 1715 by Jonathan Edwards, then of Windsor, Connecticut, but not published till 1829 in his collected works.\* Edwards was then not over 12 or 13 years of age. He relates seeing small spiders sailing through the air attached to fine strands of gossamer. He also induced small spiders to take off from a stick held in the hand. He states that spiders fly only on fine days from the middle of August to the end of October. His account is illustrated by three small sketches showing how a spider may take to the air. As one reads this juvenile composition recording the lad's first-hand observations of nature made amid the glories of Indian Summer afternoons in old New England one cannot escape a pang of regret that instead of being America's first arachnologist he was destined to become the most

\* This article was again published by E. C. Smyth in the *Andover Review* 13: 1-19, 1890, under the title, “The flying spider—observations by Jonathan Edwards when a boy.”

influential and powerful exponent in his generation of that pagan-Christian doctrine of the vileness and depravity of the human soul and a fervent believer in the wisdom and justice of eternal punishment and of the damnation of unbaptized infants. It was a loss to science and a doubtful gain for religion.

Observations by Darwin and others on spiders alighting on ships at sea indicate that they may be transported long distances through the air. There has been, however, very little information available as to the height to which they ascend. I was, therefore, very grateful for the opportunity to examine a collection of over nine hundred vials of spiders collected by airplane by Mr. P. A. Glick, of the U. S. Bureau of Entomology at Tallulah, Louisiana. The great majority of the specimens were young or so mutilated that specific determination was impossible. The following list includes only those specimens that could be determined to species.

*Spiders collected by airplane at Tallulah, Louisiana, by P. A. Glick.*

#### Family DICTYNIDÆ

##### *Dictyna bellans* Chamberlin

♂ 6:08 P. M. Oct. 3, 1930, 1000 ft.

##### *Dictyna cruciata* Emerton

♂ 2:08 P. M. May 26, 1930, 2000 ft.

♂ 2:26 P. M. June 25, 1930, 200 ft.

#### Family OECOBIIDÆ

##### *Oecobius parietalis* Hentz

♀ 2:32 P. M. Nov. 4, 1930, 1000 ft.

#### Family THERIDIIDÆ

##### *Crustulina guttata* Wider

♀ 2:03 P. M. Mar. 19, 1931, 200 ft.

##### *Theridion globosum* Hentz

♂ 11:09 A. M. Apr. 12, 1930, 1000 ft.

#### Family ARGIOPIDÆ

##### Subfamily Linyphiinæ

##### Group Erigoneæ

##### *Ceraticelus creolus* Chamberlin

♂ 8:32 A. M. July 19, 1929, 200 ft.



**Ceraticelus limnologicus** Crosby & Bishop

♂	1:51 P. M.	Mar. 12, 1930,	5000 ft.
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**Ceratinopsis atolma** Chamberlin

♂	2:43 P. M.	Apr. 5, 1930,	3000 ft.
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**Erigone tridentata** Emerton

♂	3:01 P. M.	Apr. 5, 1929,	1000 ft.
♀	1:52 P. M.	June 29, 1929,	2000 ft.
♂	4:19 P. M.	Dec. 10, 1929,	200 ft.
♂	11:35 A. M.	Jan. 4, 1930,	200 ft.
♂	2:30 P. M.	Feb. 28, 1930,	200 ft.
♂	10:09 A. M.	Apr. 5, 1930,	200 ft.
♂	9:31 A. M.	Apr. 12, 1930,	200 ft.
♂	11:20 A. M.	Apr. 12, 1930,	200 ft.
♂	2:07 P. M.	Apr. 14, 1930,	5000 ft.
♂	11:18 A. M.	Apr. 21, 1930,	200 ft.
♀	2:56 P. M.	Apr. 22, 1930,	1000 ft.
♂	8:52 A. M.	May 26, 1930,	200 ft.
♂	1:07 P. M.	May 27, 1930,	2000 ft.
♂♀	2:16 P. M.	Dec. 1, 1930,	2000 ft.
♂	2:25 P. M.	Apr. 6, 1931,	5000 ft.

**Erigone autumnalis** Emerton

♂	3:48 P. M.	Apr. 17, 1929,	1000 ft.
♂	2:47 P. M.	May 3, 1929,	2000 ft.
♂	3:43 P. M.	Jan. 24, 1930,	200 ft.
♂	11:28 A. M.	Mar. 26, 1930,	200 ft.
♂	9:20 A. M.	Apr. 12, 1930,	200 ft.
♂	1:46 P. M.	Apr. 12, 1930,	2000 ft.
♂	3:48 P. M.	May 7, 1930,	2000 ft.
♂	3:13 P. M.	Nov. 18, 1930,	1000 ft.
♂	1:52 P. M.	Nov. 28, 1930,	2000 ft.
♂	1:30 P. M.	Nov. 28, 1930,	200 ft.
♂	1:54 P. M.	Dec. 1, 1930,	200 ft.
♂	9:38 A. M.	Dec. 2, 1930,	1000 ft.
♂	3:09 P. M.	Dec. 2, 1930,	2000 ft.
♂	11:18 A. M.	Mar. 18, 1931,	200 ft.
♂	2:14 P. M.	Mar. 19, 1931,	1000 ft.
♂	2:14 P. M.	May 13, 1931,	1000 ft.
♂	2:03 P. M.	May 13, 1931,	2000 ft.
♂	8:42 A. M.	July 13, 1931,	1000 ft.

***Erigone barrowsi* Crosby & Bishop**

♂	8:35 P. M.	Aug. 5, 1929,	3000 ft.
♂	11:33 A. M.	Aug. 7, 1929,	2000 ft.

***Pelecopsis moestus* Banks**

♀	10:02 A. M.	Apr. 8, 1930,	1000 ft.
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**"*Tmeticus*" *parvus* Banks**

♂	2:51 P. M.	Jan. 4, 1930,	200 ft.
♂	3:10 P. M.	Jan. 4, 1930,	1000 ft.
♂	10:18 A. M.	Mar. 11, 1930,	200 ft.
♂	10:15 A. M.	May 28, 1930,	1000 ft.
♂	9:01 A. M.	June 2, 1930,	2000 ft.
♂	11:18 A. M.	June 9, 1930,	200 ft.
♂	2:25 P. M.	Dec. 17, 1930,	1000 ft.
♂	3:00 P. M.	Jan. 29, 1931,	200 ft.
♂	9:20 A. M.	June 3, 1931,	5000 ft.
♂	9:39 A. M.	July 10, 1931,	1000 ft.

***Walckenaera vigilax* Blackwall**

♂	1:58 P. M.	Feb. 26, 1930,	2000 ft.
♂	2:16 P. M.	Mar. 12, 1930,	1000 ft.

Group *Linyphiæ****Linyphia coccinea* Hentz**

♀	2:06 P. M.	Feb. 7, 1930,	200 ft.
♀	11:27 A. M.	Mar. 12, 1930,	200 ft.
♂	11:20 A. M.	Apr. 12, 1930,	200 ft.

***Linyphia communis* Hentz**

Young	10:39 A. M.	Feb. 1, 1930,	1000 ft.
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***Microneta meridionalis* new species (Description appended)**

♂	1:32 P. M.	Oct. 7, 1929,	3000 ft.
♂	11:07 A. M.	Jan. 31, 1930,	20 ft.
♂	10:29 A. M.	Apr. 25, 1930,	1000 ft.
♂	2:04 P. M.	June 17, 1930,	3000 ft.
♂	1:41 P. M.	Nov. 28, 1930,	1000 ft.
♂	2:09 P. M.	Dec. 19, 1930,	2000 ft.
♂	1:52 P. M.	Jan. 2, 1931,	2000 ft.
♂	3:22 P. M.	Jan. 2, 1931,	1000 ft.
♂	3:00 P. M.	Jan. 29, 1931,	200 ft.
♂	2:40 P. M.	June 4, 1931,	2000 ft.

**Microneta micaria** Emerton

♀	3:04 P. M.	Apr. 5, 1930,	1000 ft.
♂	3:27 P. M.	May 26, 1930,	1000 ft.

## Subfamily Tetragnathinæ

**Mimognatha foxi** McCook

♂	2:18 P. M.	Apr. 21, 1930,	3000 ft.
♂	10:53 A. M.	Mar. 19, 1931,	200 ft.

## Subfamily Argiopinae

**Araneus stellatus** Walckenaer

Young	11:14 A. M.	Dec. 13, 1930,	1000 ft.
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**Mangora placida** Hentz

♀	2:51 P. M.	Jan. 4, 1930,	200 ft.
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## Family SALTICIDÆ

**Dendryphantes capitatus** Hentz

♂	8:22 A. M.	Sept. 11, 1929,	20 ft.
♂	8:26 A. M.	Oct. 14, 1929,	2000 ft.
♂	10:31 A. M.	Mar. 24, 1931,	1000 ft.

**Synemosyna formica** Hentz

♂	3:21 P. M.	Sept. 18, 1929,	3000 ft.
♂	10:41 A. M.	Oct. 13, 1930,	20 ft.

**Wala palmarum** Hentz

♂	2:30 P. M.	July 20, 1931,	1000 ft.
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**Microneta meridionalis** new species Crosby & Bishop

MALE. Length, 1.5 mm. Described from a fairly light specimen. Cephalothorax dusky over light orange yellow, viewed from above broadly oval, rounded across the front with the anterior eyes in profile; viewed from the side, moderately ascending behind, then gently arched to the eyes. Clypeus gently concave, slanting forward. Sternum dark gray over pale yellow. Endites and labium pale yellow strongly suffused with gray. Chelicerae pale orange yellow lightly suffused with gray. Legs yellowish. Abdomen light gray crossed by four or five light broad chevrons.

Posterior eyes in a straight line, equal, the median separated by the radius and a little nearer the lateral. Anterior eyes surrounded by black in a straight line, the median smaller than the lateral, separated by the radius and a little nearer the lateral.

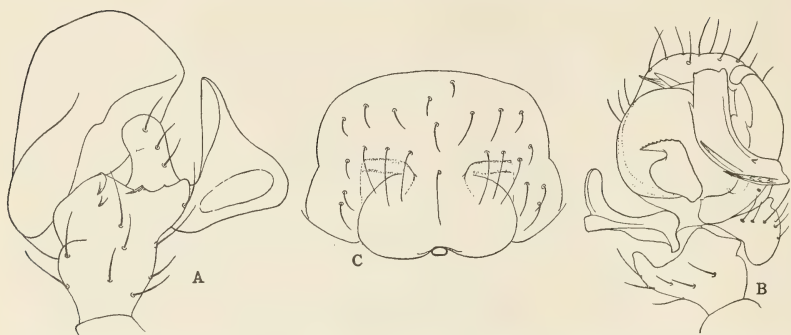


FIGURE 1. *Microneta meridionalis*. A, ♂, right palpus, dorsal view; B, same, ventral view; C, ♀, epigynum.

The palpus is of the same type as in *unimaculata*. The femur and patella are much the same as in that species. The tibia is depressed before the tip and widened on the lateral angle, dorsally there is a short ridge ending in a black tooth directed backward and followed behind by a more slender tooth; laterally from this ridge the margin is broadly concave, armed with a small triangular tooth a little back of the margin in the middle and a much smaller one nearer the lateral angle. Basally the cymbium is slightly produced into two rounded lobes, the lateral one distinctly granulate. The paracymbium is of the same type as in *unimaculata* but it is wider at the bend and the end is shorter and wider. The embolus is curved and lies across the bulb; it is grooved in the basal half; the lower flange is serrate, the last two teeth being long and spine-like, the upper flange has one small tooth; the duct opens on a minute tubercle on the inner face of the embolus on the lateral bend; beyond it the embolus is continued into a rounded point. The radix is crescent-shaped, relatively longer than in *unimaculata* and the rounded projections on its inner face more slender. The median apophysis has the black tooth a little stouter and the margin of the thin part is smooth, not frayed. The terminal apophysis is shorter and broader with the lateral side broadly rounded, the thinner tip is obliquely triangular with the edge minutely serrate.

**FEMALE.** Length, 1.7 mm. Similar to the male in coloration, a distinct white spot just above the spinnerets. Femora of legs black at base. Last two segments of palpus somewhat enlarged and nearly black. The epigynum is of the same type as in *unimaculata* but somewhat more protuberant. The basal part of the scape before the enlargement is narrower and the lateral cavities turn strongly inward at this point.

Holotype, male; allotype, female, Lucedale, Mississippi. Oct. 16, 1930 (Henry Dietrich).

Louisiana: Tallulah, May 25, 1934, 1 ♂ (Folsom); June 19,

1934, 3 ♂, 1 ♀ (Folsom). For the other Tallulah records see the preceding list.

Mississippi: Lucedale, Jan., 1931, 1 ♂; Dec. 4, 1930, 1 ♂ (Dietrich); State Line, Mar. 19, 1931, 1 ♂, 5 ♀ (Dietrich).

Florida: Rock Bluff, April 4, 1927, 1 ♂ (Hubbell); Bunnell, Feb. 21, 1927, 2 ♂ (Leonard); Micanopy, Mar. 6, 1927, 1 ♂ (Barrows).

Virginia: Franklin, Notaway River bottom, Oct. 28, 1926, 1 ♂.







## SYNOPSIS OF THE TABANIDÆ OF NEW YORK, THEIR BIOLOGY AND TAXONOMY

### I. The Genus *Chrysops* Meigen

BY BERNARD SEGAL

UNIVERSITY OF ROCHESTER

#### INTRODUCTION AND ACKNOWLEDGMENTS

This paper was begun in 1931. The work, as then outlined, was to consist of a study of the extensive literature on the family, a study of the insects in the field and in the collection, and life history studies of the species most common in the vicinity of Rochester.

In conformity with the first part of the work program, more than one hundred papers on Tabanidæ in English, German, and Russian were studied. Thanks are due to many authors who sent me reprints of their works, especially to Dr. Von O. Kröber (Hamburg) for authorization to adapt his classification of *Chrysops*.

The insect collection of the University of Rochester contains all the species of New York State, most of them identified by Johannsen. These were thoroughly studied from the anatomical and taxonomical aspects. Several visits were also made to Cornell University for the purpose of studying the Tabanidæ in the collection of the College of Agriculture. To Dr. J. Chester Bradley, curator of the insect collection, I am indebted for a liberal loan of many specimens representing species not available for study in our collection.

The vicinity of Rochester affords many ideal places for the study of Tabanidæ in nature. Durand-Eastman Park, situated on Lake Ontario, with its three ponds and swampy, wooded areas, is an excellent breeding ground for the flies. The many acres in the park devoted to the preservation of wild animal life, particularly deer and buffalo, offer plenty of food for the blood-sucking females. The swamps near Bergen, situated about twenty miles west of Rochester, are during the summer months dominated by

the horse-flies, particularly *Chrysops*. The swamps are surrounded by pasture lands where hundreds of cattle graze daily. The group of ponds known as Mendon Ponds near Rochester is also a favorable breeding place for horse-flies. There are wooded areas on the hills surrounding the ponds on one side and horse stables on the other side. The larger species of tabanids are particularly common in Mendon Ponds.

In the course of the study two species of *Chrysops*, *indus* and *obsoletus*, were reared from egg to adult. One species of *Tabanus* was likewise reared through all its stages. Many other species found as larvæ were observed in the laboratory in the course of their development into adults.

The attempt to study the embryology of some tabanids was unsuccessful due to the insoluble black pigment in the chorion of their eggs. The work will, however, be repeated in the coming season.

My studies were conducted in the entomological laboratory of the Department of Biology of the University of Rochester under the direction of Dr. J. Douglas Hood, without whose advice and guidance this work would have been impossible.

#### ECONOMIC IMPORTANCE AND CONTROL

Of all the Tabanidæ, *Chrysops* species most readily attack man. Many a specimen has been obtained by simply waving the net around the head. This affords a good protection from the bites of the flies and yields a large number of specimens in a comparatively short time. But then the collection will consist of females only, for they alone attack man and beast for the purpose of blood sucking.

The bite of the female is not very painful, but the continuous buzzing and pricking, particularly on the back of the neck and on the forehead, is extremely annoying. There seems to be a preference among the various species for certain specific parts of the host body. Some prefer the lobe of the ear, others the back of the hand, or various other exposed parts of the body. *Chrysops* species are not common on cattle, but they molest horses, and in the tropics they torture the elephant and the lion, and the reindeer, as well as man.

The puncture causes a small bleeding wound, but no pain is felt, except for a feeble twinge when the proboscis is withdrawn. No swelling results from the bite, and consequently no poison is conveyed into the wound by the piercing organs.

Some species of *Chrysops*, in common with other Tabanidæ, are mechanical transmitters of infectious diseases to man and animals. The nature of the transmission is not certain in all cases. Some are experimentally proven while others are based on circumstantial evidence. All the cases of disease transmission in which *Chrysops* species are involved or suspected of being involved are here discussed:

1. Tularemia of man: This is an infectious disease due to *Bacterium tularense* which is transmitted to man by the bite of an infected blood-sucking fly or by handling infected rodents.

The blood-sucking fly which serves as the mechanical transmitter of the disease germ is *Chrysops discalis*, as proven by Francis and Mayne (1922). This species is very common in Utah, Colorado, Wyoming, and Washington. It has also been reported from other states of the Union. The disease is particularly common in rural districts among the field workers. The two conditions favorable for the spread of the disease are (1) the presence of infected rodents, and (2) the season of the fly's activity, which is June, July, and August, when farm labor is at its peak.

The disease is initiated by the bite of the fly on the face, neck, or exposed parts of hands or legs. The victim is not conscious of the bite; it is not painful. After the bite the infection sets in with fever and inflammation of the lymph glands in the vicinity of the bitten area. The illness is accompanied by a disability to do any work for two or three months. This means a loss in time and efficiency during the busiest season for the farmer. The virus, however, does not multiply inside the fly, and after five days of isolation the tendency to infect a healthy animal decreases.

2. *Loa loa*: This is a disease of man in tropical West Africa. It is caused by the parasitic nematode *Filaria loa* Guyot. Two species of *Chrysops*, *dimidiata* and *silacea*, have been demonstrated by Leiper (1913) and by the Connolls (1922) to be concerned in the development and in the transmission of the parasite.



The embryos of the parasite pass through the mid-intestine of the fly and reach the thorax, where they remain coiled up in the thoracic muscles. On the twelfth day the development is complete and the embryos begin to travel towards the head, collect at the base of the proboscis, and pass into the hæmocœle in the labium. About 3.5 per cent of *Chrysops dimidiata* and *Chrysops silacea* are infected with the parasite in nature, and the two species are very common in the infested districts during May and June. The transmission is effected while biting the host. During that time the insect keeps on "milking" the labium with the forelegs, and the embryos rupture the walls of the labella and fall on the skin of the host. The embryos move rapidly, enter the skin, and in a very short time disappear beneath the surface.

3. In common with other Tabanidæ, species of *Chrysops* may be vectors of tsetse sickness of cattle, *Trypanosoma theileri* of sheep, *Trypanosoma evansi* (surra) of cattle, and *Trypanosome equinum* of the horse, and also in the transmission of swamp fever or infectious anemia of horses.

#### METHODS OF CONTROL

##### A. Biological Control.

###### I. Parasites on the eggs of *Chrysops*.

1. A minute hymenopteron, *Phanurus emersoni* Girault, belonging to the family Mymaridæ, is one of the most important parasites on the eggs of Tabanidæ. The female inserts the ovipositor into the chorion of the fly-egg where it deposits its eggs. Fresh egg-masses seem to be preferred to older ones, as it takes longer to puncture eggs over five or six hours old. About 93 per cent of all the egg-masses studied in Texas were found to be parasitized, and from six to 83 wasps emerged from each egg mass.

Investigators suggest a means of control by collecting the egg-masses and placing them in vessels along the river, these vessels being so constructed that they do not allow the parasite to escape, and serving to retain fly-larvæ inside later to be destroyed. A 50 per cent decrease in horseflies is reported in localities where parasite dissemination was supplemented by egg collecting.

2. *Phanurus tabanivorus* Ashmead has been reared from the eggs of several species of Tabanidæ.

3. *Trichogramma minutum* and other chalcids were reared in small numbers from eggs of Chrysops.

## II. Parasites of Larvæ.

Larvæ are not open to successful attack because of their underground habitat. But there are several forms that feed on them.

1. Soon after hatching the young larvæ fall into the water where they molt prior to burrowing into the mud. At that time many are devoured by small fishes.

2. Jones and Bradley (1923) report *Phasiops flava* Coq. of the family Tachinidæ, and *Villa lateralis* Say of the family Bombyliidæ to be parasites on tabanid larvæ. They are also hosts to tachinid larvæ which eviscerate them.

3. Mature larvæ are sometimes infested by nematodes, particularly in the pre-pupal period.

4. Cannibalism reduces their number considerably.

## III. Parasites of the Pupa.

Cameron and Philips report two Chalcids to be parasites of the pupa. They are *Trichopria tabanivora* Fauts and *Diglochis occidentalis* Ashmead.

## IV. Parasites on Adults.

1. For about 30 minutes after emergence from the pupal case the flies are unable to fly as the wings are folded and are shorter than normal, and the abdomen is enlarged. At that time they fall an easy prey to predaceous Hemiptera, Odonata, and other insects.

2. Mites are often found on the bodies of the flies.

3. Birds capture the flies on the wing, and spiders entrap them in their nets and devour them.

4. The white-faced hornet (*Vaspa maculata* L.) has been observed to paralyze the fly and then dismember it by biting off the wings, the head and the abdomen, leaving only the thorax which is carried to the nest.

5. The horse-guard (*Monedula carolina* Drury), a predaceous wasp, is among the more important checks on the horsefly. These wasps lay their eggs in burrows and watch over them until they hatch. As soon as larvæ appear, the wasps supply them

with food, which consists of horsefly adults. The wasp frequents pastures where they pick the flies off the molested horses and cattle and carry them to their nests.

6. *Bembex*, another predaceous wasp, soars at about a man's height, and swoops down on the horsefly below, stings it, and paralyzes it immediately. It is then carried to the burrow as food for the young of the wasp.

Tabanidæ are said to be scarce where these wasps are present in great numbers, and their introduction is advocated as a means of control.

### B. Physical Control.

By this term is meant the climatic and geographical factors that influence the increase or decrease of the flies.

1. Tabanids are most abundant after heavy rainfall in the summer. The breeding grounds are multiplied during such seasons. On the other hand such seasons are most unfavorable for the development of parasites, as they thrive in seasons of much sunshine.

2. Bodies of water and arboreal plants are the chief conditions for the existence and multiplication of horseflies. Where these conditions are absent Tabanidæ are scarce.

3. Tabanids favor the neighborhood of rivers, pools, and swamps, wooded areas and clearings, and the open roads in woodland.

### C. Mechanical Control.

The mechanical means of control may be divided into three groups: (1) Repellents, (2) trapping, and (3) screens.

1. Several mixtures have been recommended for use as sprays and external applications, as well as for internal administration, for the purpose of repelling the flies. These consist of kerosene, tar-oils, and fish-oil emulsions for external use, and various salts for internal use.

None of these remedies has proved to be satisfactory preventives. Their effectiveness is of short duration and does not justify their high cost and labor. Many of these mixtures, besides being useless as far as relief is concerned, may be harmful to the hair and skin of the animals.

2. The habit of tabanids of flying frequently over the surface of water was utilized by the Russian entomologist Porchinsky to devise a method of trapping the flies in what he calls "pools of death." The pools most frequented by the flies are kept covered with a uniform layer of oils and the insect sticks to the surface of the water and perishes. Those that succeed in escaping perish subsequently since the oil spreads over the body causing suffocation by clogging the air passages.

This remedy was reported by Howard at the XIth meeting of the Association of Economic Entomologists in 1899. The limitations of the remedy were pointed out at the meeting, since only small, stagnant pools can be converted into "pools of death." It cannot be applied to large, moving, or inaccessible bodies of water.

3. A fly-trap devised by M. Bourgault du Cordroy for *Stomoxys* could well be adapted for the relief of stock from tabanids. The trap is simple and inexpensive, and the results are said to be effective and rapid. It consists of:

a. A darkened, partitioned building, with entrance and exit doors.

b. A brush of leaves and branches.

c. A lighted chamber into which the flies are attracted and where they are trapped and destroyed.

The building is erected at a convenient place in the pasture land, and the herd is passed single file through the brush. After the first day, the cattle are said to go at a gallop to the trap to free themselves of the flies. A black, tailless, animal may be used as a decoy for the flies, and when a number of flies have collected on its body it is passed through the brush.

This trap, while its effectiveness is highly praised, can only be constructed on large cattle-raising ranches. Its cost would be prohibitive for the small-scale breeder or individual farmer.

4. The harassed animals themselves seek relief from the flies. Congregating during the most annoying hours of the day in groups, they seek protection in the shade of trees, and in the shelter of open sheds.

Horses and oxen at work are covered with hoods of burlap or nets over the head and neck. Holes are cut in the hoods for the eyes, ears, and nostrils.



5. Drainage of swamps and marshes, clearing and cultivating these areas, is the only radical measure that would conduce to a substantial eradication of most of the horseflies. It would cut off their breeding beds and the moisture necessary for development.

The difficulties connected with a large-scale measure of this kind are obvious.

#### HABITS

##### 1. Food habits:

The larvæ of *Chrysops* subsist on the organic matter that is found in their habitat in soil, slime or decaying leaves. In the laboratory they thrive in a medium rich in decayed organic matter. They are never tempted by animal food even when no other food is given. The larvæ devour the soil and extract whatever organic matter there may be in it, much after the fashion of earthworms. Unlike the *Tabanus* larvæ *Chrysops* larvæ are not cannibalistic. Stammer (1924) kept five larvæ in the same dish for four weeks, and they did not attack one another although no other animal food was given. The stomach contents consisted entirely of the fine slime in which he reared them. We kept larvæ of *Chrysops indus* and *Chrysops obsoletus* and never noticed any case of cannibalism. In nature they are usually found in aggregations in a small space, while the cannibalistic *Tabanus* larvæ are widely disseminated in the soil.

Some investigators found that the larvæ of *Chrysops callidus* were carnivorous and cannibalistic at least during the early instars. We could not verify this tendency in the two species reared by us.

Jones and Bradley were unsuccessful in their attempts to rear tabanid larvæ in nutrient agar. These investigators also observed that the larvæ feed very little during cool days.

The adult female is blood-sucking, while the male subsists on nectar from flowers and plant juices. But while the male has never been observed to bite animals, the females visit flowers, extract juices of fruit and sap of trees when no animal food is obtainable. They are found in abundance in regions where large mammals are scarce, and where they could hardly satisfy their thirst for blood. The presence or absence of the flies in the Alps

is said to be wholly conditioned by climatic and topographic factors, and very slightly by the presence or absence of cattle. Sometimes a coat of pollen is found on the bodies of female specimens collected in the field.

One is led to believe that these flies were originally zoophagous in both sexes. The hoematophagy of the female and the phytophagy of the male are secondary developments. Zoophagy is still preserved in the larvæ to some degree, while in the adult female, due to the fact that the prey attacked is too large to be devoured totally, hoematophagy, which is a convergent of zoophagy, was adopted. The phytophagous habit is a later adaptation to which the males are adjusted by the morphological changes in the feeding apparatus, and the female is still in the process of adjustment.

## 2. Drinking.

In the discussion on control reference has been made to the peculiar habit of *Tabanidæ* in visiting bodies of water. The purpose is not known; it may be for drinking. Both sexes are frequently observed hovering over the water, lowering themselves at intervals to the surface, and dipping the proboscis in the water. At the time the ventral surface of the body is in contact with the surface of the water.

## 3. Flight.

While the buzzing of the larger tabanids is recognized from a distance, the quiet flight of the deer-flies is hardly heard. They circle around the head and suddenly disappear. They are rapid fliers and are said to follow trains or cars for long distances. They are especially attracted by dark and moving objects.

## 4. Bite.

The place of biting is peculiar to every species. I noticed that *Chrysops obsoletus* prefers the exposed part of the hand, while *Chrysops indus* bites on the back of the neck. When the fly alights on its victim it explores a small area with the labella prior to piercing the skin. In order to get blood the mandibles must pierce through the epidermis. The prick is felt distinctly, but no pain is experienced while the fly is ingorgating. After a

complete meal which lasts about 10 minutes the walls of the gut of the fly are greatly stretched. The blood goes directly to the stomach where it is present as a fluid. This suggests the presence of an anti-coagulin secreted by the salivary glands which prevents the coagulation of the blood. There is no reservoir for the blood in the crop as is the case in the tsetse flies. The crop contains a watery, colorless fluid which is believed to be saliva as in the cockroach, or juices obtained from the surface of plants as in mosquitoes.

Veil and gloves are necessary as protection from bites of *Chrysops* in the Florida Everglades. They penetrate heavy flannel army shirts and riding breeches.

An interesting problem is presented by the fact that the number of larvæ of a particular species is not found in the same proportion as the adults of that species in a locality. Cameron found the proportion to exist in the northern regions of Canada, but Webb and Wells could not find such correlation to exist in Antelope Valley, and Philips (1926) found conditions in Minnesota which point to the fact that the most abundant species of larvæ were least represented as adults. Snyder (1917) was unable to find any great number of larvæ or exuvia in the Everglades of Florida where the adults are extremely numerous. The banks of the three lakes in Durand-Eastman Park yield very few larvæ of *Chrysops indus*, while the adults of this species are dominating the Park in the Summer. Upon discussing this matter with Dr. J. D. Hood, he called my attention to a similar condition existing in the case of some dragonflies where the adults are found far from the habitat of the larvæ. The explanation was offered that this is done for economy in food supply. This may also be true for *Tabanidæ*.

#### BREEDING METHODS

The egg mass found in the field is carried into the laboratory with the plant on which it is fixed, and placed in its natural position in a dish or bottle containing some water on its bottom. As soon as the larvæ hatch they are drawn out of the water by a pipette and placed into dishes containing wet sand or water-soaked dead leaves. After the first molting they are transferred

into permanent vessels in which natural conditions of habitat are simulated.

The breeding of Chrysops larvæ is much easier and simpler than that of the carnivorous and cannibalistic *Tabanus* larvæ. They are saprophagous and hence a layer of soil rich in decayed organic matter, kept moist, will provide sufficient nourishment. They are not cannibalistic and therefore can be reared in groups without the necessity of individual care.

The methods employed by the various investigators differ according to locality and purpose. The early workers used boxes or glass jars containing damp earth and decayed organic material. This medium while it simulates closely natural habitat is not convenient for observation on the activities of the larvæ, habits of feeding, and for keeping records of ecdysis and growth. Modifications of this method were used by Hart, Hine and others.

Issaac (1914), working in India, used clean sand instead of earth. The early instars were kept in small beakers, and the older larvæ were transferred into jelly jars. The sand was kept moist all the time, and the jars were covered with gauze and petri dishes to prevent escaping. The sand layer was tilted to allow a moisture gradient. Before observation, an excess of water was added to each jar or beaker and the contents shaken gently. This brought to the surface the larvæ, cast skins, food material, and refuse. After all observations were completed, measurements made, and waste material cleaned, the sand was again allowed to settle by tilting the vessel on one side, the excess of water poured off, and the larvæ allowed to burrow in the sand. Issaac was the first to record on the number of larval instars.

Stammer (1924), in Germany, reared his Chrysops larvæ in glass dishes filled with moist sand and slime. The dishes were covered with heavy lids to prevent escape.

Patten and Cragg in India, reared large numbers of tabanids in trays of galvanized iron about six inches deep. The trays were filled with sand and mud sloped off to simulate the shore of a stream or pond. Water plants were planted in the mud and the trays were always kept about three-fourths filled with water, preferably from a stream. The water was changed every ten days through a hole bored in the bottom of the tray, near one



corner and stopped with a cork. The egg masses were collected and as soon as they hatched the young larvæ were transferred into the trays. The vessels were stocked with earthworms and decayed organic matter. When mature, the larvæ were removed from the trays and placed in jars with mud. The mature larvæ burrowed into the mud and pupated just under the surface. The pupæ were then placed in cages covered with mosquito netting.

The cages contained iron trays filled with mud. Holes were made in the mud and the pupa placed in them. The netting was stretched over a framework of iron rods to allow penetration of sunshine and to prevent the escape of the emerging adults.

Mitzmain, working in the Philippines on *Tabanus striatus*, reared the flies in a capacious fly-proof building with brass gauze sides and top, and cement floor. The building was sufficient to house four or six animals and thousands of flies. The building contained a concrete water tank with plants growing in it.

For breeding on the work-table in the laboratory a simple and convenient method has been developed. It is based on the realization that the chief responses of the larvæ are: (a) negative phototropism, and (b) positive thigmotropism.

The larvæ will thrive in any surroundings where these two responses are satisfied. For this purpose glass vials or test tubes that are laid out with strips of filter paper or ordinary paper toweling are used. The paper is kept moist to substitute for the damp mud. It affords opportunities for contact of the body with something, and a medium to hide in. The vials are covered with pieces of cheese cloth and tied around with rubber bands to prevent escape and at the same time to keep down evaporation and allow plenty of fresh air. The pupæ are transferred into jars or trays with mud.

In our work we used flat glass dishes with sand and decayed leaves, as well as vials with filter paper. Both proved to be satisfactory.

#### COLLECTING CHRYSOPS LARVÆ

Chrysops larvæ can be collected at all times of the year in mud and soil above the water level and near the edge of any permanent body of water. They are usually found about two inches underground, and several ways of obtaining them are suggested.



When only a few specimens are desired, the procedure is to wade into the water along a steep margin and to loosen the soil by means of a garden hand fork or horticultural hand weeder. A handful of water is poured over the loosened soil and the larvæ will show up on the surface.

Another method is straining the mud through an ordinary wire kitchen-sieve. A lump of mud is taken from the edge of the water and placed in the sieve. The sieve is immersed in the water and gently shaken. The dirt is washed through the wire meshes and the larvæ soon show up clinging to grass roots or weeds.

But these methods of collecting are obviously not suitable for cold winter days. The process would also be impracticable when larger quantities of larvæ are desired. In such cases other methods have been suggested.

The mud is brought to the laboratory in a tin container. Water is added to form a thin, muddy fluid which is stirred gently and passed through a sieve. The larvæ are caught in the mesh of the sieve.

We followed the methods of Stammer. Blocks of mud which were dug up in the field were brought into the laboratory and spread over a screen wire laid over a basin with some water on the bottom. The larger larvæ were noticed while the mud was being broken, and those not picked up in this way dropped into the water as soon as the layers of mud dried.

The larvæ are differentiated from other dipterous larvæ in the same habitat by: (1) prominent, downward projecting mandibles, (2) glossy sheen of the integument, and (3) sub-cylindrical form of the body with rings of projecting forelegs on the abdomen.

#### MATING AND OVIPOSITION

In the early hours of a summer day, usually before sunrise, the sexes of Chrysops species in common with other *Tabanidæ* gather at their "meeting places" on the hill summits or in the foliage of trees near water, where copulation takes place. Mating has been observed at rest and on the wing.

Oviposition is stimulated by the presence of water and by vegetation overhanging or projecting out of the water. Eggs were

never found on stones and wood or away from the water. As a rule oviposition takes place in the morning, but it has also been observed in the afternoon hours of warm days in June and July. The process occupies about half an hour. The fly is very sluggish during that time and is not easily disturbed. Hine (1906) carried a fly with the leaf, on which she was ovipositing, into the laboratory, took a picture, and made detailed observations of the act, while the fly continued to lay the eggs apparently undisturbed. The great number of unfinished egg masses found in the field would indicate, however, that they readily leave off in the middle of the act. A female of *Chrysops moerens* continued ovipositing while I watched closely for about 20 minutes, turning the blade of the sedge several times. But she suddenly fled without any cause, leaving the mass unfinished. The place on the leaf, kind of plant, and the distance from the ground do not seem to have any specific significance. The process of ovipositing was first described by Hine and later also by Cameron and other investigators. The process in brief, as observed by the author in *C. indus*, on cat-tail, is thus:

The female alights on the leaf head downwards and moves around feeling the surface with the tip of the abdomen before starting to lay the first egg. Then the tip of the abdomen is recurved antero-ventrally beneath the abdomen. A protruding egg is glued to the surface of the leaf and the abdomen is then brought back to the normal position. This frees the egg. By repeating these movements more eggs are deposited on both sides of the first egg in single, oblique rows until a mass of from 100 to 300 eggs is formed in a single layer. Each egg is brushed lightly by the ovipositor as it is laid. Before laying a new egg the preceding egg is touched lightly, probably for the purpose of orientation. Each egg is laid so as to overlap its predecessor, leaving only about one-third of it exposed. The eggs are glued to one another and to the surface of the leaf by a secretion. The whole mass is then covered by a thin, water-proof, insoluble, protective membrane. The egg mass presents a flattened, elongate, gray or creamy-white spot, tapering at both ends or, when unfinished, the lower end is truncate.

The mass is grayish when freshly laid, but gradually gets darker until it becomes brown or lustrous black in color. The darkening is quicker when exposed to sunlight.

#### THE EGG

The individual egg is semitransparent and contains a whitish mass of yolk in its upper third. It is cylindrical in form with rounded ends. Only about one-third of each egg is visible at the surface of the mass, the rest being covered by the following egg which obliquely overlaps it. The egg is about 1.5 mm. in length, and about .25 mm. in diameter. It is straight or slightly curved, broader in the middle and gradually narrowing toward the ends.

The eggs are believed to be laid soon after fertilization, for in sections made of these eggs no great development was observable. A blood meal is essential to the maturation of the eggs. The duration of the egg stage depends upon the temperature. It varies from five days in sunshine to seven days when kept in the shade.

The eggs of a single mass hatch in nearly the same time, and the young larvæ leave through a slit in the chorion at the upper pole of the egg. The egg-cluster at that time presents a wriggling whitish mass. The larvæ are very active and crawl one upon the other, clinging together, and presenting moving lumps which soon loose their hold upon the black egg-shells and drop into the water. The lumps sink to the bottom and the larvæ separate, each burrowing into the sand or mud, after molting.

#### THE LARVÆ

The larvæ ecologically belong to the hydrophytic area. From hatching to the approach of cold days the larvæ feed and grow. They become dormant and stop feeding late in the fall when they burrow deeper into the soil. They resume feeding in spring and are found full-grown in April and May.

The full-grown *Chrysops* larva is 10-15 mm. long and 1-3 mm. wide. The body is yellowish white or light brown in color, sometimes with a greenish tinge, with pale or brown pubescence. The integument is transparent and shiny, due to the longitudinal striae of the chitin.

The head capsule, usually darker than the body, is small and can be completely telescoped into the thorax. The mandibles are dark in color and slightly curved ventrally. The antennæ are distinct and composed of three joints; basal joint small, the others of varying length. The apical joint is bifid. The ocelli are dorsal in position, and consist of a single, dark, irregular optic spot on either side of the head capsule.

The thorax is composed of three distinct segments with a dark girdle of pubescence of varying width on the anterior margin of each segment, and a pair of ventral bristles. The thorax bears a pair of spiracles which are situated laterally in the boundary line between the prothorax and the mesothorax.

The abdomen consists of eight segments, the last being modified into an anus and a respiratory syphon (Cameron considers the syphon as a separate segment, the ninth). Segments 1-7 are capable of being slightly telescoped into one another when in motion. Each segment usually bears an anterior dorsal band of pubescence and rarely also a posterior ring of pubescence. Each of the abdominal segments, 1-7, possess a pair of transverse fused dorsal prolegs, a pair of distinct strong lateral prolegs, and a pair of rounded ventral prolegs. The prolegs are situated on the anterior portion of each segment and present a heavily chitinized ridge circling around the segment. The lateral and ventral prolegs bear rows of recurved setæ which aid in locomotion through the relatively compact soil.

The anal segment is longer than the preceding segments, terminating in a short subconical syphon which is capable of retraction and extension. Several dark spots of pubescence on the anal segment are of use in classification. The syphon bears a dorsal spiracle in which the two tracheal trunks terminate. The spiracle is in the form of a protrusile spine or in the form of a vertical slit. This is used by the mature larvæ to break the surface film of the water for the exchange of air when they are submerged.

The larvæ are metapneustic, the first, prothoracic pair of spiracles being non-functional. Two main tracheal trunks of a shining silvery color are conspicuously visible through the transparent integument. They run all the length of the body, parallel at their anterior portion, and coiled in the sixth and seventh abdominal segments, coming in contact again in the syphon.



The intestines usually show through the integument, as filled with a colored fluid, depending on the food. The dorsal blood vessel and the coiled Malpighian tubules are also seen through the chitin.

A unique structure in the larvæ of Tabanidæ is the organ discovered by Graber in 1878 and called Graber's organ. It is situated on the dorsal side of the anal segment between the two tracheal trunks. It is the structure that attracts immediate attention with its black, oscillating bodies in the living specimen. The organ consists of the following parts:

1. The principal chitinous sac.
2. Smaller, secondary, chitinous capsules enclosed within the principal sac.
3. Black globular bodies suspended in the fluid filling the capsules.
4. A muscular mechanism by which the organ is moved pendulum-like when the larva is in motion, and
5. Nerve attachments and membranes to maintain the position of the black bodies.

The entire organ is piroform in shape. The wider fundus tapers gradually to a slender thread-like tube which opens dorsally in the furrow between the anus and the syphon. The organ according to Cameron is probably an invagination of the integument and the black bodies are modified cuticular hair.

When the body is at rest the organ is practically stationary, but with the slightest movement the suspended black bodies begin their lateral oscillations. The number of the black bodies is variable in the various species. Only the principle sac is functional. The other smaller capsules within it are remains of the sacs of the earlier instars which persist after molts. New black bodies appear after each molt, but the old ones remain unfunctional in the capsule all through the larval stage. In some mature larvæ the number and the arrangement of the black bodies is constant enough to warrant their use in classifications. In *Chrysops* larvæ there are usually four pairs of black bodies, and only those suspended from the anterior wall of the main capsule are functioning.

The function of the organ has been interpreted by many workers.



1. *Auditory*. Graber who studied the organ in detail, in 1882, believed it to be for the purpose of hearing. The sac, accordingly, would be an otocyst and the black bodies, otholiths. The difficulty with this view is the apparent uselessness of an auditory organ for a larva living underground.

2. *Glandular*. Lecaillon (1906) denies any sensory function to the organ and would rather assign to it a glandular function, that of secreting pigment.

3. *Sound-producing*. Paoli (1907) believes that Graber's organ is responsible for the clicking noise produced by some of the larger tabanid larvæ. It has been pointed out since then that the noise is caused by the telescoping of the segments of the abdomen during locomotion.

4. *Static*. The function assigned to the organ by Cameron (1926), and which is generally accepted, is that of maintaining the equilibrium and orientation of the body. The black globular bodies accordingly assume the role of sensory hair which are stimulated by the movements of the fluid in the capsule when the larva is in motion. The impulses are transmitted through the nerve attachments to the ganglia of the central nervous system. They are then conveyed to the muscles of the body causing them to perform coordination contractions by which equilibrium and orientation of the organism is effected.

#### THE PUPA

Late in April and in May the full grown larvæ of *Chrysops* move nearer toward the surface for pupation. The larvæ become sluggish and stop feeding entirely. They enter the pre-pupal period which lasts from one to two days prior to pupation.

This stage is characterized by:

1. The transformation of the prothoracic spiracles into white, slender tubes projecting laterally and anteriorly at the base of the prothorax. Respiration during the prepupal stage is amphipneustic.

2. Partial retraction of the head.

3. Slight swelling of the prothorax.

4. The initial development of the external features of the pupa that can be seen through the integument of the larval skin.

The pupa emerges out of the larval skin by pressing forward and causing a longitudinal split on a mid-dorsal line of the thorax. The head is freed first and the exuvium is then pushed backwards by contractions and expansions of the abdomen, assisted by the fringes of pupal bristles on the abdominal segments. The pupa usually lies in an erect position in compact soil above the water level.

*Chrysops* pupæ are brownish-yellow in color and measure from 10–15 mm. in length, and 2–3 mm. in diameter. The head and the thorax are fused. Short antennæ overlies the eyes; and the space between them is variously cleft and furrowed with ridges of chitin.

The thoracic spiracles projected in the pre-pupal stage are now flattened and extend out dorsally. The wing pads are short, barely reaching the second abdominal segment.

Abdominal segments 2–7 are distinctly divided into dorsal, lateral, and ventral areas. Each lateral area bears a spiracle. A comb of dorso-lateral pupal spines surround each abdominal segment, except the first, on the posterior margin. The anal segment bears six sharp projections on its posterior end. These form the pupal aster, which consists of three pair of projections: one pair directed dorsally, a larger dorso-lateral pair, and a ventro-posterior pair. Each projection terminates in sharp, re-curved hooks.

The pre-anal fringe and sometimes the aster offer a means of distinguishing the sexes. In the pre-anal fringe of males the bristles are of equal size; in females the row is broken in the middle. The anal region is, generally more protuberant in males than in females. The size and strength of the astral hooks differ in the sexes.

The pupal period is of varying duration, ranging from five days in the field to two weeks in the laboratory.

An interesting case of pupal adaptation has been reported by Lamborn (1929) from Nyasaland. It concerns the ability of the pupa to survive in dry mud.

The writer noticed smooth discs at the intersection of the cracks in the dry mud about the size of a penny, in a hollow which served to collect water in the rainy season. These discs were

slightly concave and perfectly circular with an opening about the diameter of a lead pencil in the center. Each disc proved to be the top of a cylinder of mud about  $3\frac{1}{2}$  inches in height which could be readily removed from the ground. Inside of each cylinder was found a pupa or a pupal shell.

The cylinders were presumably constructed by the larvæ when the mud was plastic by spiral movements. With the drying of the upper layers of the mud during the dry season the larvæ moved gradually downward where the moisture was still present. At the desired depth the larvæ burrowed in the mud to pupate, sealing the entrance to the cylinder. When ready to emerge the pupa breaks through the seal of the cylinder by the aid of the pupal armaments on the head, and the imago escapes.

The cylinders then serve:

1. To protect the larvæ from sudden exposure to heat when the cracking of the mud takes place,
2. To allow the pupa to move up and down so as to escape the heat during midday hours,
3. To retain moisture, necessary for the organism, and
4. To protect against attack of enemies.

#### THE ADULTS

Toward the end of the pupal period the pupa moves toward the surface with the aid of the fringes and aster, ready for emergence of the adult. This is accomplished by a slit in the dorsum of the thorax and by breaking the plate of chitin covering the head. The adult on emergence remains motionless for about half an hour, clinging to blades of grass near the deserted pupa-case. They are then in the teneral stage. The wings at that stage are much shorter than the enlarged abdomen. After the emission of a yellowish meconium through the anus, and the stretching of the wings, the fly attempts to take wing for short distances.

The adults are on wing from May to August, the season of greatest activities being July and August. The span of life of the female is longer than that of the male.

The life cycle of *Chrysops* is believed to be one year. The difference in size often found in larvæ of the same species may be due to food and to differences in time of hatching, since the egg-laying season stretches over a period of over two months.

The one-year life cycle can be summarized thus: Incubation, about 1 week; Larval period, about 10 months; Pupation, from 1 to 2 weeks; Imago, about 2 months.

## KEYS TO THE IMMATURE STAGES OF CHRYSOPS

The immature stages of *Chrysops* can be distinguished from other New York *Tabanidæ* by the aid of the following keys:

## EGGS

(After Hart)

1. Arranged in a single tier lying flat on the surface of the object, and overlapping one another upwards; egg mass forming an oval or diamond-shaped area at one or both ends ..... *Chrysops*
- Laid at an angle to the surface on which it is deposited, in more than one tier ..... 2
2. Creamy white at the time of hatching ..... *Goniops*
- Dark brown or black at time of hatching ..... *Tabanus*

## LARVÆ

1. Body club-shaped, thoracic segment slender, abdominal segments robust ..... *Goniops*
- Body tapering anteriorly and posteriorly, not club-shaped ..... 2
2. Apical antennal segment much longer than the preceding segment, usually bifid; diameter of main trachial trunks the same over the entire length; dorsum of thoracic segments nearly as striated as those of abdominal segments. Small size. Range between 10-15 mm. .... *Chrysops*
- Apical antennal segment not larger than the preceding segment; diameter of main tracheal trunks more inflated in the posterior part of the body than in the anterior; dorsum of thoracic area nearly free from striæ. Large size. Range when mature, between 15-50 mm. .... *Tabanus*

## PUPÆ

1. One spine on each side of median line on dorsum of each abdominal segment much stronger than the others in the series ..... *Goniops*
- Spines of each series almost of a uniform strength ..... 2
2. Antennæ surpassing adjacent margins of head, about twice as long as the width at the base, bristles on frontal tubercles double; abdominal spiracles slender, subcylindrical near apex. Small size, range between 10 to 15 mm. .... *Chrysops*
- Antennæ not projecting beyond lateral margin of head; length about equal the basal width; frontal bristles single; abdominal spiracles subconical or rounded; of medium or large size, range between 15-35 mm. .... *Tabanus*

## KEY TO THE ADULTS OF CHRYSOPS

(After Hine)

*Chrysops* may be distinguished from the other genera of *Tabanidæ* commonly occurring in New York by the aid of the following key:



- A. Hind tibiae with spurs at tip.
  - B. Third segment of antennae composed of eight rings, the first of which is only a little longer than the following ones.....
  - C. Front of female narrow; ocelli present or absent; fourth posterior cell at least open .....*Pangonia*
  - CC. Front of female broad with a large denuded callus; ocelli present; wings in both sexes with a dark picture.....*Goniops*
  - BB. Third segment of antennae composed of only five rings, the first of which is much longer than the following ones. Second segment as long or but little shorter than the first; eyes in life with green patches .....*Chrysops*
- AA. Hind tibiae without spurs at tip; third segment of antennae with a well developed basal process .....*Tabanus*

## KEY TO THE NEW YORK SPECIES OF CHRYSOPS

(After Kröber)

- 1. Apical spot and cross-band of the wing completely fusing together, and occupying the entire apical part, except for a circular hyaline area in the region of the first submarginal cell .....Group I *bistellatus*
- Apical spot, when present, distinctly separated from the cross-band by a hyaline triangle on the posterior margin of the wing.....2
- 2. Wings without apical spot, or represented by a faint shading on the apex of the wing. Cross-band not quite reaching the posterior margin of the wing, leaving at least a fine hyaline border in the distal end of the fourth posterior marginal cell .....Group II *excitans*
- Wings with a distinct apical spot .....3
- 3. Antennal joint 3 shorter than joint 2 .....Group III *ceras*
- Antennal joint 3 longer than 2 .....4
- 4. Antennal joint 1, or 1 and 2, thickened or club-shaped.
  - Group IV *virgulatus*
  - Antennal joints cylindrical, slender .....5
- 5. Both basal cells of wing hyaline, or with only a small band of infuscation at their very tips, the area of infuscation never exceeding the clear area in the cells .....Group V *callidus*
- Area of infuscation in the first basal cell greater than the clear area, or the cell is entirely filled with brown .....Group VI *vittatus*

Of the six groups constructed by Kröber for the *Chrysops* species of North America, I is not represented in the New York insect fauna, but has been recorded from New Jersey (*Chrysops bistellatus* Daecke, Ent. News, XVI, p. 249, 1905). Group II is represented in New York by eight species; Group III contains only two species, both from Mexico; Group IV includes six species, of which one, *brunneus*, is found over the entire area east



of the Rocky Mountains; the other five species being confined to Mexico and the Pacific Group. Groups V and VI are represented in New York by 12 and 9 species respectively.

Group I. *Bistellatus*

Abdomen yellow with two dorsal longitudinal stripes. Wings infuscated on the apical half, with a hyaline quadrate in the first submarginal cell ..... *bistellatus* Daecke

Group II. *Excitans*

- A. Abdomen entirely black without any light marking.
- B. Cross-band on wing faintly outlined, obscure beyond the discal cell. Basal cells clear ..... *nigribimbo* Whitn.
- BB. Not as above.
- C. Cross-band distinctly dark-brown, nearly reaching the posterior margin in the fourth posterior cell. Basal cells brown.
- Pleura on thorax with thick reddish-yellow tufts of hair. .... *celer* O.S.
- Pleura with tufts of gray hair ..... *niger* Macq.
- D. Fifth posterior cell with circular hyaline spot at base. .... *carbonarius* Walk.
- DD. Fifth posterior cell brown at base ..... *mitis* O.S.
- AA. Abdomen with gray or yellow markings, or triangular median spots.
- E. Cross-band very distinct, light or dark-brown.
- F. Abdominal segments with narrow, gray posterior borders; yellow lateral spots small ..... *sordidus* O.S.
- FF. Abdomen without gray posterior margins of segments. Yellow lateral spots large. Tergite 2 with yellow median triangle ..... *excitans* Walk.
- EE. Cross-band not distinct, pale brown, interrupted below the discal cell. Second tergite without gray or yellow triangle at middle, black with gray lateral spots ..... *cuclux* Whitn.

*Chrysops carbonarius* Walk.

(*Chrysops carbonarius* Walker. List of Diptera, British Museum I: 203, 1848.)

Length 8.5–9.5 mm. Antennæ 2–2.2 mm., wings 8–8.5 mm. long, 2.5–3 mm. wide.

*Female.* General body color black with a gray silky pubescence. Wings hyaline with a dark brown picture.

Head:—Face covered with yellow pollen. Callosities shining black. Frontal callosity rectangular with a sharp tapering point

reaching the large, dark, ocellar area on which are situated three reddish ocelli. Antennæ slender: joint 1 light brown, joint 2 reddish brown, furrowed; both joints with thick short black bristles. Joint 3 black, style indistinctly annulated. Front and vertex clothed with black hair.

Thorax:—Shining black, thickly clothed with delicate whitish hair. A row of long black hair on the sides of the thorax extend from the base of the thorax to the base of the wings. Pleura with three conspicuous white tufts of hair, the one near the base of the wing particularly thick. Near the base of the thorax is a circular area of a lighter hue, and on the sides are round light patches. Legs black, metatarsi reddish brown. Pubescence short, black, with rows of longer whitish hair on the inner side of the femora.

Wings infuscated at the base, in the costal and subcostal cells, over the proximal halves of the two basal cells. Cross-band covers the proximal halves of the marginal, first submarginal and first posterior cells; touches upon the apex of the first basal cell and fills completely the discal cell. The posterior border extends over the proximal one-quarter of the second posterior and obliquely over the one-half of the third posterior cells; it nearly fills the fourth, and touches slightly on the base of the fifth posterior cell. The rest of the fifth posterior cell, the axillary cell, the anal cell, the apical halves of the two basal cells and the apex of the wing, hyaline.

Abdomen:—Black, with whitish hair on the posterior borders which tend to form median triangular patterns on tergites 2 to 4. Venter black clothed with the characteristic white hair.

*Male.* Similar to female.

Distribution:—Maine to Minnesota; Quebec to Colorado.

Synonyms:—*ater* Macquart, 1850; *fugax* Osten-Sacken, 1875.

*Chrysops celer* O.-S.

*Chrysops celer* Osten-Sacken, Memoirs Boston Society Natural History, II: 376, 1876.

Length 8.5–9 mm., antennæ 2.5–3 mm., wings 8.5–9 mm. long, 2.8–3.2 mm. wide.

*Female.* General body color lustrous black with a silky yellow pubescence. Thorax with two median bluish-gray longitudinal

stripes and tufts of long ferruginous hair on the sides. Wings hyaline with a dark brown picture.

Head:—Face covered with reddish yellow pollen. Callosities shining black. Ocellar area black and irregular in outline. Ocelli reddish brown. Front and vertex covered with pale yellow pollen and yellow hair. Antennæ long and slender, joint 1 ferruginous, darker at the tip; joint 2 slightly furrowed, dark on the outer sides and at the tip; both joints beset with strong black bristles; joint 3 reddish brown at the base, the rest of the joint and the curved annulated style black.

Thorax:—Thickly clothed with silky yellowish hair which on the pleura form very conspicuous tufts of reddish hair. Two longitudinal stropes of a bluish-gray color are discerned on the anterior, but hardly reach beyond the mid-dorsal line. Legs black; metatarsi of the middle and hind legs yellowish, pubescence black with a mixture of gray on the femora.

Wings infuscated at the base, in the costal and subcostal cells, over the proximal three-fourths of the two basal cells, and at the very base and apex of the anal cell. Cross-band intensely brown and with nearly parallel: it covers the proximal halves of the marginal and the first posterior cells, touches upon the apices of the two basal cells, fills completely the discal cell, the fourth and fifth posterior cells, and obliquely extends over the base of the second and the proximal half of the third posterior cells. A very narrow border of diffused infurcation separates the cross band from the inner margin of the wing. Apex of the wing, axillary cell, middle of basal cells and most of anal cell, hyaline.

Abdomen:—Tergites black with narrow light posterior borders and short grayish pubescence. Rudiments of median triangles are faintly outlined by silvery white hair on tergites two and three. Venter black with grayish hair, on the last sternite.

*Male.* Uniformly black. Pubescence black including the characteristic thick tufts on the pleura. Infurcation on the wings more intensely brown than in the female, and fills the entire anal cell as well as the greater part of the basal cells.

Distribution:—Long Island to Minnesota; Province of Quebec to Kansas.

Synonym:—*cincticornis* Walker, 1848.

*Chrysops cuclux* Whitn.

(*Chrysops cuclux* Whitney, Canadian Entomologist II: 35, 1889.)

Length 7.5–8 mm., antennæ 2.1–2.2 mm., wings 7–7.5 mm. long, 2.5–2.9 mm. wide.

*Female.* General body color lustrous black. Thorax with two rudimentary longitudinal grayish spots. Abdomen with faint reddish brown spots on the first and second tergites. Pubescence generally silky gray. Wings cloudy hyaline with a very pale brown picture.

Head:—Face covered with silky gray pollen. All callosities shining black. Ocellar area wide and black with three reddish brown ocelli. Front and vertex with long gray and silky gray pollen. Antennal joint 1 light brown, darker at the tip; joint 2 brown, deeply furrowed at the middle; both joints clothed with short black bristles. Basal part of joint 3 brownish, the rest of the joint and the short annulated style black with brownish hue.

Thorax:—On the anterior part of the dorsum are two grayish stripes which hardly reach one-third the length of the thorax. Pubescence delicate and gray; pleura with thick tufts of long gray hair. Legs black, the metatarsi of the middle and hind legs brown. Pubescence on all parts black, front femora with long grayish hair.

Wings infuscated at the base, in the costal and subcostal cells, and on the proximal two-thirds of the two basal cells. Cross-band follows a nearly straight line from the stigma towards the inner margin of the wing. It covers the upper halves of the marginal and submarginal cells, touches upon the apices of the two basal cells, fills completely the discal cell, extends over the proximal half of the first posterior, about one-third of the second and third posterior cells, and faintly shades the fourth and fifth posterior cells. Along the anal cell the brown fades into the grayish hyaline of the anal cell, the axillary cell and the apex of the wing.

Abdomen:—Clothed with a gray silky pubescence. Tergites 1 and 2 with lateral contiguous spots of a reddish brown color. The hair on these lighter areas are whiter and longer than the general pubescence of the tergites. Similar white hair tends to form median triangular patterns on tergites 2 to 4. Venter black, each sternite with a light posterior border. The gray hair is uniformly distributed and are longest on the last sternite.



Male unknown.

Distribution:—Maine to Minnesota; Quebec to Pennsylvania.

Synonyms: *cuchix*, Ricards, 1911.

*Chrysops excitans* Wlk.

(*Chrysops excitans* Walker, Diptera Saundersonia, or characters of undescribed insects in the collection of W. W. Saunders. Diptera I: 72, 1850.)

*Female*. Length 10.5–11.5 mm., antennæ 2.4–2.5 mm., wings, 9.5–10 mm. long, 3–3.5 mm. wide. General body color black. Thorax with faint greenish longitudinal stripes. Abdomen with yellowish median and lateral spots. Wings hyaline with a light brown picture.

Head:—Face covered with pale yellow pollen. All callosities shining black. Front and vertex beset with long grayish hair, particularly thick on the ocellar area. Antennal joint 1 reddish yellow, gradually turning dark towards the tip; joint 2 dark brown on the outer side, yellowish on the inner side, furrowed. Both joints covered with thick black bristles. Joint 3 longer than 1 and 2, with a short style on which four annuli can be distinctly seen.

Thorax:—Lustrous black with two greenish longitudinal stripes, separated by a median narrow purplish line. The stripes are bordered on their outer sides by a reddish longitudinal stripe which does not reach the mid-dorsum. Pubescence reddish-yellow, which on the pleura forms thick turfts of hair particularly long at the base of the wings. Legs black with a yellow tinge on the femora.

Wings infuscated at the base and in the costal and subcostal cells, over the proximal three-fourths of the two basal cells, and at the very base of the anal cell. The cross-band is comparatively narrow and undulating; it covers the proximal halves of the marginal, first submarginal and first posterior cells; touches the very apices of the two basal cells and fills the entire discal cell; it extends over the proximal one-fourth of the second and third posterior cells, faintly fills the fourth and the proximal half of the fifth posterior cells, and tinges the apex of the anal cell. Apex of wing, axillary cell and a border on the inner margin of the wing hyaline.

Abdomen:—Tergite 1 black with a light posterior border which forms a median crescent-shaped spot, with its gray hair very distinct from the surrounding black pubescence. On either side is a reddish yellow spot of varying patterns. Tergite 2 with a light posterior border which broadens into a triangular median spot, the apex nearly reaching the middle of the tergite. Two lateral spots similar to those on tergite 1 and contiguous with them. Tergites 3 to 6 black with light posterior borders and rudiments of median spots indicated by gray hair more delicate and longer than the general black pubescence.

*Male.* Similar to female in most characteristics. Abdomen lacks the triangular and lateral spots. Picture of the wing more intensely brown than in the female.

Distribution:—Maine to Minnesota; Ontario to District of Columbia.

*(To be concluded)*

## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF DECEMBER 18, 1934

A regular meeting of the Society was held on December 18, 1934, in the American Museum of Natural History with Vice-President Schwarz in the chair and twenty-three members and nine visitors present.

Dr. Roland F. Hussey was elected an active member of the Society.

Mr. and Mrs. M. R. Frank were proposed for membership.

Dr. A. B. Klots read his paper, the second in the series on the subject "Present Problems of Species Concept." An abstract of Dr. Klots' paper appears below, under the title "Viviparity in Insects."

Dr. Klots' paper was discussed by Messrs. Ruckes, Horsfall, Moore, Curran, Weiss, Speith and Bird.

Dr. Moore declared, in part, that hybrids in evolution are not given enough importance by the evolutionist; and also, that physiological differences are just as valuable as structural differences in establishing a species.

Dr. Ruckes stressed the importance of one mutation arising from the presence of other mutations; also, he mentioned the breeding season as an important factor in dealing with this problem.

ELIZABETH S. ENGELHARDT, *Secretary*

## VIVIPARITY IN INSECTS

The embryologist recognizes three types of bigametic reproduction, *i.e.*, *oviparity*, *ovoviviparity*, and *viviparity*. In the field of insect embryology, examples of the first and last groups are well-known and clear-cut, but those of the second category are quite unsatisfactory for observing stages in development from the time of fertilization to the instant of hatching, because developing eggs of different insect species vary a great deal. In certain cases (*Orenia*, Coleoptera; some Plectoptera) eggs hatch in less than a minute after deposition. My personal opinion is that oviparity refers to laying of eggs in which the chorion is intact while viviparity applies to the bearing of live young that have been freed from the enveloping chorion, if indeed, the latter membrane be present at all. It is wanting, for instance, in all Strepsiptera, all Polycetenidae, *Hemimerus*, (Orthoptera) and parthenogenetic aphids. Therefore, the term ovoviviparity in this connection is superfluous.

Several attempts have been made to classify the types of insect embryological development. Holmgren's plan has been most widely cited and generally used. Comstock adopted and improved upon it by inferring but not actually using a physical basis of separation. It appears that viviparous insects illustrate four types of viviparity, when physical and physiological adaptations on the part of the parent and her offspring are considered; these are:

1. *Ovoviviparity*:—The eggs are passed into the uterus with an adequate supply of nutriment (yolk) to bring the contained embryos to full growth by hatching time. The only clearly visible adaptation is the distensibility of the maternal uterus which in expanding serves as a reservoir for the developing ova until they hatch. A psychic change in the parent no doubt

occurs, for she must become accustomed to the presence of a cluster of eggs and later hatched young in her uterus (Chrysomelidæ, Sarcophagidæ).

2. *Adenotrophic viviparity*:—In these cases (flies) the eggs are supplied with sufficient yolk to carry them through hatching, but one pair of accessory glands of the parent discharges fluid into the uterus upon which the larvæ feed until full grown. Deposition is then immediately followed by pupation. Here again physical, psychical, and physiological changes take place in the female parent and the offspring is modified too.

In the larvæ only an oral opening fitted with a sucking tongue represents the former mouth and buccal armature; the musculature has largely disappeared and the mid-intestine no longer connects with the protodæum; psychically they have changed from active voracious maggots to placid creatures waiting for food to come to them. Correlated with this type of development we find that the parent bears only one offspring at a time; the adult repeatedly bears young, however, throughout her entire mature life. (*Glossina* and the Pupipara).

3. *Exgenital viviparity*:—The mature ovaries rupture and eggs are dispersed into the hæmocoel, where development proceeds at the expense of the maternal tissues, especially the fat bodies. In *Miastor* the yolk is sufficient to carry the development of the egg to hatching but the larvæ literally eat their "mother." In some Strepsiptera the embryonic serosa absorbs nourishment for the embryo since the ovum has little or no yolk; in others, where more ovarian nutriment is present, this process is considerably delayed. The female is pædogenetic in *Miastor* and the escaping larvæ (10 to 25 in number) cause her death. In the Strepsiptera the oviducts do not function during "birth" and the hundred of triungulinids are carried through brood canals and brood chambers to the outside without killing the parent.

4. *Pseudoplacental viviparity*:—In these cases the egg does not possess a chorion and the embryo soon establishes a physical union with the maternal tissues. No yolk is present but a small amount of a fatty substance is available for the first few developmental divisions. The pseudoplacenta may be a permanent structure (Hemimerus). In the Polyetenidæ the outer embryonic wall forms an absorbing layer which rests against the inner surface of the oviduct. In all these cases the young are born singly and at intervals throughout the life of the parent.

The detailed adaptations of both parent and young are too numerous and profound to be discussed in this report. A few have been suggested in the above outline.

Viviparous insects reported, in addition to those cited above, are given in the following list. Doubtful cases are questioned.

1. Oviparous: *Carotoca*, *Spiractha* (Staphylinidæ); several Tachinidæ; Aphidæ and several Coccidæ; *Tinea* and *Colias* (Lepidoptera); *Blatta*, *Blabera* (Orthoptera); *Chloon* (Plecoptera)?; *Megathrips* (Thysanoptera); a species of Anopleura.

3. Exgenital: *Micromalthus* (Coleoptera); *Tanytarsus* (Diptera); all species of Strepsiptera.



# The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943.

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

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JUNE, 1936

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# JOURNAL

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VOL. XLIV

JUNE, 1936

No. 2

### NINE NEW THYSANOPTERA FROM THE UNITED STATES\*

By J. DOUGLAS HOOD  
UNIVERSITY OF ROCHESTER

#### *Heterothrips xolismæ* sp. nov.

♀ (macropterous).—Length about 1.0 mm. (slightly distended, 1.15 mm.). COLOR brown or blackish brown, with tarsi and third antennal segment yellow, fore tibiae with about distal third and the extreme base yellow or yellowish, the intermediate portion brown, fore femora and middle and hind tibiae yellow or yellowish at extreme apex; fore wings dark brownish gray except for a transverse white band near base.

HEAD of normal form, without the postocular angulation found in some species, somewhat broader across cheeks than across eyes, the cheeks nearly straight and slightly converging posteriorly; ocellar area and eyes at posterior margins delimited by a dark but not heavy chitinous line, the transverse occipital groove thus not prominent, the occipital area with about five anastomosing dark striae; front of head slightly excavated as usual in front of ocelli but without a pair of deep pits behind the first antennal segments; frontal costa with the emargination U-shaped. EYES of normal form and structure, nearly as wide as their interval, measuring as follows ( $\mu$ ) in holotype: dorsal length 70, width 46, interval 51—these measurements being to the edges of the facets. OCELLI of posterior pair about  $14\mu$  in diameter,  $24\mu$  apart, and  $18\mu$  from median ocellus, the latter smaller, its diameter  $10\mu$ . ANTENNÆ nearly 2.2 times the length of pronotum and very nearly twice the greatest width of head, of normal form and structure, the segments shaped much as in *H. borinquen* (see Ins. Insc. Menstr., 3(1-4), Pl. I, fig. 1), except that segment V is narrower and not at all abruptly narrowed at base; segment III about 2.85 times as long as greatest width, its length from base to third incision about half the length of IV.

PROTHORAX about 0.9 as long as greatest width of head and about 1.5

\* The types of the new species described below are in the author's collection.

times as wide as its own median length, broader posteriorly, with sides and posterior margin broadly rounded and anterior margin nearly straight; notum with a few faint lines of sculpture at margins, only, the main portion of disk perfectly smooth, its setæ small and inconspicuous. MESONOTUM with distinct dark striæ, the transverse ones fully  $3\mu$  apart. METANOTUM without differentiated scutellum. WINGS of fore pair with about 32 setæ on costal margin, 26 on anterior vein, and 21 on posterior vein.

ABDOMEN stout (as is usual in the genus) and sharply pointed; microtrichia totally wanting, except on segments VIII and IX; posterior margins of terga I-VII fringed at sides with chitinous scales or plates whose distal margins are very evenly produced into short slender spines whose length is not more than one-fifth or sixth of that of the whole plate, the structure thus almost exactly as in *H. flavicornis* (see Ins. Insc. Menstr., 3(1-4), Pl. I, fig. 3); tergum I broadly bare across middle of posterior margin, II-V each usually with a few slender spines forming a comb at middle, but sometimes with as few as one or two such spines on the more basal terga; VI-VIII with the comb continuous and unbroken.

Measurements of ♀ (holotype), in mm.: Length about 0.99 (slightly distended, 1.15); head, length 0.111, width across eyes 0.143, greatest width across cheeks 0.146, least width near base 0.141; prothorax, median length 0.132, greatest width 0.202; mesothorax, greatest width 0.258; metathorax, greatest width 0.235; fore wings, length 0.690, width at middle 0.037; abdomen, greatest width 0.325.

Antennal segments:	1	2	3	4	5	6	7	8	9
Length ( $\mu$ ):	24	35	77	47	25	26	17	15	20
Width ( $\mu$ ):	30	26	27	28	19	17	12	10	7
Total length of antenna 0.286 mm.									

*Type*.—♀; Odenton, Maryland. June 20, 1915. (W. L. McAtee; in flowers of *Xolisma ligustrina* [Hood No. 31]).

*Paratypes*.—6 ♀♀; same data as types.

Although taken on a plant closely allied to the one on which *H. lyonia* is very common—a plant which most authorities now place in the genus *Lyonia*—this thrips is evidently quite distinct from any other North American species. In the character of the abdominal plates or scales its only ally in the temperate zone is *H. salicis*. This, however, has much shorter and stouter antennæ, with particularly stout intermediate segments. The other species of the Eastern United States, *H. lyonia*, *aesculi*, *azaleæ*, *arisaemæ*, and *limbatus*, all have the abdominal plates either produced into long, slender spines or else (in *limbatus* only) forming an unbroken series across the whole posterior margin of the second to fifth terga. The Panamanian *H. flavicornis*, with

which it well agrees in this detail of structure, is very different in color and in its heavy pronotal sculpture.

Genus **Sericopsothrips** nov.

(σηρικόν, silk; ὄψις, aspect; θρίψ, a wood-worm—in allusion to the silky appearance of the abdomen.)

Near *Sericothrips*. Head broad, finely cross-striate, its front nearly vertical above antennæ, the median ocellus directed forward. Eyes rounded, strongly protruding, coarsely faceted, pilose. Maxillary palpi three-segmented. Antennæ eight-segmented, with U-shaped sense-cones on segments III and IV. Pronotum crossed by numerous close, raised, anastomosing lines, and with one pair of long setæ at posterior angles. Legs moderately long and slender, tarsi especially slender. Fore wings with *anterior vein irregularly and sparsely setose in basal half, the distal half with two setæ only, these near apex; position of posterior vein marked by three setæ, one of them at middle of wing, the other two beyond.* Abdomen pubescent at sides, posterior margins of basal terga with delicate comb behind the pubescence, VIII with complete comb; segment IX not closely joined to X, its tergum with *only four pairs of major setæ on dorsal and lateral surfaces; X long and slender.*

Genotype: *Sericopsothrips palloris* sp. nov.

The single species upon which this genus is based is excluded from *Sericothrips* by the chaetotaxy of the fore wings and abdomen, and by the structure of the last two abdominal segments. It is of more than usual interest because it serves to connect the *Sericothrips* group of genera with the ordinary Thripid type in the characters which have been italicized in the description above, and because it leads us to suspect that the posterior vein of the fore wing of *Sericothrips* has been lost through degeneration rather than by fusion with the ambient vein.

**Sericopsothrips palloris** sp. nov.

♀ (macropterous).—Length about 1.0 mm. (distended, 1.16 mm.). COLOR of body and legs uniform yellowish white; wings colorless; all body and wing setæ colorless; antennæ with first two segments concolorous with body; third similarly pale in pedicel and basal half or more, then shaded with grayish, darkest at extreme tip; fourth darker than third, especially at apex, and similarly colored, but with a clear band just beyond pedicel; fifth darker in basal half than fourth, somewhat paler than fourth at apex, its pedicel dark and concolorous with tip of fourth, with a clear band just beyond pedicel; sixth to eighth uniform gray-brown, but paler than apex of fourth.

HEAD much broader across eyes than elsewhere and nearly twice as wide as median length, cheeks nearly straight and converging posteriorly, occipital

line wanting but posterior margin of head thickened; dorsum of head closely and very delicately cross-striate with anastomosing lines which do not produce a serration of the cheeks; setæ comprising four subequal and nearly equidistant ones in front of median ocellus (the median pair more anterior in position), a third pair within the ocellar area, closer together than diameter of median ocellus and arising about on the line of front margins of posterior ocelli, a fourth pair about  $23\ \mu$  long almost directly behind middle of posterior ocelli, a fifth equally long and slender pair behind and external to the last and close to eyes, a sixth and seventh pair on dorsal surface of cheeks just behind eyes, and an eighth pair on lateral outline of cheeks just behind the last two pairs. EYES very prominent, protruding, their posterior margins about  $26\ \mu$  from that of head, their dorsal length  $53\ \mu$ , width  $42\ \mu$ , and interval  $62\ \mu$ . OCELLI about  $17\ \mu$  in diameter, the posterior pair about  $26\ \mu$  apart. ANTENNÆ about 1.9 times as long as width of head across eyes, segments formed as in *Sericothrips*; segment VI not pedicellate, its sense-cones attached at base only; inner seta near apex of segment II about  $30\ \mu$  long, pale yellowish in color, more than twice the length of the outer seta; setæ on III-VIII light brownish, the inner dorsal on III about  $28\ \mu$ . MOUTH-CONE extending nearly to base of prosternum, its length (measured from base of labrum) about  $95\ \mu$ .

PROTHORAX with the pronotum about 0.7 as long as width of head across eyes and 1.5 times as wide as long, the raised, transverse, anastomosing lines distinct, delicate, and evenly and closely spaced (about 6 of them in  $10\ \mu$ ), nowhere tending toward reticulation; setæ all slender, pointed, one long outstanding pair ( $50\ \mu$ ) near posterior angles, the others short and subequal. MESONOTUM sculptured like pronotum, perhaps a little less strongly. METANOTUM nearly smooth, with faint polygonal subreticulation at middle. FORE WINGS nearly 16 times as long as width at middle; costal margin with about 25 pointed setæ (those at middle of wing about  $34\ \mu$ ) and 26 fringing hairs; longitudinal vein with a basal group of 3 setæ followed immediately by 4 (all confined to basal two-fifths of wing) and then by 2 or 3 widely spaced ones; posterior vein not evident, but its position apparently indicated by three widely spaced setæ in distal half of wing. LEGS long and slender, the femora, tibiae, and tarsi of the hind pair measuring, respectively, in length (and width) as follows: 140(34), 175(30), 97(17)  $\mu$ .

ABDOMEN broadest at segment IV, tapering posteriorly, but with segments IX and X not closely united to form a conical unit, IX being rounded distally, X (+XI) long ( $92\ \mu$ ), slender ( $52\ \mu$ ), somewhat narrowed basally, and tapering only slightly to tip; abdominal pubescence close and pale, lacking from median portions of terga; comb complete only on posterior margin of VIII; median pair of setæ on I, VIII, IX, and X longer than their homologues on II-VII, those on IV-VII respectively about 16, 17, 18, and  $25\ \mu$ , those on I about  $30\ \mu$ ; the two dorsal pairs on VIII subequal and about  $38\ \mu$ , posterior lateral pair  $57\ \mu$ ; IX with a pair of strong setæ ( $43\ \mu$  long and  $38\ \mu$  apart) at distal third, and three pairs of long setæ near posterior margin, the first of these approximate,  $53\ \mu$  long, and only  $13\ \mu$  apart, the second dorso-



lateral in position and  $73\ \mu$  long, the third ventro-lateral and  $63\ \mu$  long, the last two pairs strongly diverging as in most Thripidae, a pair of minor setæ between the posterior dorsal and dorso-lateral setæ just described but closer to posterior margin of segment, a second minor pair above and somewhat posterior to the ventro-laterals, and beneath this minor pair either one or two pairs on sides of segment, in addition to several pairs originating on ventral surface; X with a dorsal pair ( $54\ \mu$  long and  $8\ \mu$  apart) near tip, a shorter and slenderer dorso-lateral pair, and several minor ones.

Measurements of ♀ (holotype), in mm.: Length about 1.04 (distended, 1.16); head, median dorsal length 0.073, width across eyes 0.145, greatest width across cheeks 0.130, least width near base 0.126; pronotum, median length 0.103, width 0.158; mesothorax, greatest width 0.242; metathorax, greatest width 0.227; fore wings, length 0.714, width at middle 0.045; abdomen, greatest width (at segment IV) 0.259.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	24	40	55	48	44	49	8	14
Width ( $\mu$ ):	27	28	21	20	17	17	9	5
Total length of antenna 0.282 mm.								

Described from 1 ♀ taken by the author at Canandaigua Lake, N. Y., May 29–30, 1934, from a species of *Vaccinium* growing on an arid hillside [Hood No. 568].

In general appearance the species is in all respects a true *Sericothrips*.

***Sericothrips chrysothamni* sp. nov.**

♀ (macropterous).—Length about 1.0 mm. (distended, about 1.2 mm.). COLOR pale, with numerous brown markings; fat-body pigmentation of pterothorax and last abdominal segment largely orange-colored, of remainder of body whitish yellow, as seen by reflected light, duller and more grayish as seen by transmitted light; general color of head pale brown, darkest in the ocellar region, along cheeks, and across back of head, permitting the whitish internal pigmentation to show through the remaining portions, thus indistinctly encircling the eyes with whitish and giving an area of whitish across the whole front of head; prothorax cream-colored by reflected light, with a distinct, unbroken, brown, pronotal blotch whose anterior margin is concave and sharply defined, and whose posterior margin is deeply and roundly emarginate at middle and thus bilobed; pterothorax with an orange-yellow cast (due to the internal pigmentation), the front and sides of the mesothorax shaded with dark brown, the metanotum with its anterior portion bearing a brown blotch which is nearly as wide as the pronotal one and which is in the form of a transverse hexagon whose posterior side is emarginate, and from each of whose two anterior and two posterior angles radiates a narrow brown spot; abdomen with last four segments brown or blackish-brown, the posterior portions of VII and X disclosing the whitish internal pigmentation; anterior part of abdomen much paler, its extreme sides brown;

tergum I with a brief, transverse, dark line on each side of middle near base, II-VII each with a narrow, transverse, nearly black line at base, II-VI shaded with brown posterior to this line; ventrally the head is brown, but paler in the basal portion of the mouth-cone, the large meso- and metasternal plates and the last four abdominal segments deep brown, the remainder of the abdomen almost uniform cream-colored, except at sides; antennæ, by reflected light, nearly white in segments I and II, distinctly whitish in III-V, the distal portions of these last and all of VI-VIII gray-brown; by transmitted light, especially in caustic-treated specimens, III-V are seen to be successively darker, and darker than I and II, III lightly gray just beyond pedicel and darker at extreme tip, IV shading to gray-brown in distal half or less, V darker throughout, shading to gray-brown in about distal half, but not quite so dark at extreme tip as IV, VI-VIII nearly uniform gray-brown; legs with all coxæ dark brown, remainder largely whitish by reflected light, the fore femora shaded with brown only along outer surface, the middle femora similarly shaded and with a dark cloud just beyond middle, the hind pair much darker, their basal two-fifths pale, remainder brown, shading to pale at extreme tip; all tibiæ pale, shaded with brown along outer surface at middle, all tarsi pale (save for the brown cups); fore wings almost uniform pale yellowish, lightly shaded with gray in basal portion of scale, and with a small distinct cloud at basal third, setæ on costal margin, scale, and anterior vein, brown; ocellar pigmentation red.

HEAD broadest across eyes, cheeks rounded and slightly converging to base, somewhat serrated because of short, raised lines of sculpture which do not extend onto dorsum of head; ocellar area and posterior margin of head elevated, striate with anastomosing lines, the intervening portion forming a smooth transverse groove; front of head cross-striate; setæ as usual in the genus (*i.e.*, four subequal and nearly equidistant ones in front of median ocellus, the median pair more anterior in position, a third pair just outside a line tangent to outer margins of median and posterior ocelli, one pair ( $28\ \mu$  long) just behind posterior ocelli and slightly external to their outer margins—this last pair inclined forward and with their points just meeting—two minute pairs posterior to the last and close to the eyes, two pairs on dorsal surface of cheeks just behind eyes, one nearly lateral pair in front of middle of cheeks, and another pair ventral to and behind the last). EYES prominent, protruding, pilose, extending to within  $12\ \mu$  of the posterior margin of the head,\* their dorsal width  $46\ \mu$ , dorsal interval  $63\ \mu$ , ventral width  $42\ \mu$ , ventral interval  $71\ \mu$ . OCELLI about  $11\ \mu$  in diameter, the posterior pair  $28\ \mu$  apart and  $17\ \mu$  from median ocellus. ANTENNÆ about 1.74 times as long as width of head across eyes, segments formed as usual in this section of the genus; III about  $53\ \mu$ , IV about  $45\ \mu$ , each with a short, U-shaped sense-cone, that on III about  $17\ \mu$  long; VI not pedicellate, its two long sense-cones attached

\* The posterior margin of the head merges so gradually into the membrane connecting the head with the pronotum that its exact limit cannot be accurately determined; and for convenience I have, perhaps arbitrarily, taken as its posterior margin that of the dark-colored portion.

at sides and forming narrow pale lines, of which the inner originates near middle of segment and the outer somewhat beyond; setæ on III and IV, and inner dorsal seta on II, moderate in size and brownish, the inner dorsal on III about 28  $\mu$ , the outer dorsal on II minute and pale. MOUTH-CONE extending about to base of prosternum, its length (measured from base of labrum) about 120  $\mu$ , the three segments of the maxillary palpus 23, 14, and 20  $\mu$ , respectively.

PROTHORAX with the pronotum about 0.7 as long as width of head across eyes and about 1.7 times as wide as long, the transverse anastomosing lines not prominent, more closely spaced in the area of the pronotal blotch than in front of it, nowhere tending toward reticulation; setæ of normal size and arrangement, the large, light-brown, outstanding pair near posterior angles about 52  $\mu$ . MESONOTAL PLATE about 134  $\mu$  in extreme width, simply and moderately closely striate (about 6 transverse striæ in 10  $\mu$ ). FORE WINGS about 21 times as long as width at middle; costal margin with about 25 setæ, longitudinal vein with a basal group of 3 followed by about 18; one additional seta near tip of wing, between and behind the last two on longitudinal vein; setæ on costal margin and longitudinal vein respectively 47 and 37  $\mu$  at middle of wing. LEGS normal.

ABDOMEN thoroughly typical; pubescence distinct, lacking from median portions of terga I-V, excepting across the extreme base of IV and V; comb complete only on posterior margin of VII and VIII, sometimes weak and irregular on the former; major abdominal setæ brownish yellow.

Measurement of ♀ (holotype), in mm.: Length about 1.0 (distended, 1.19); head, median dorsal length of dark portion 0.073, width across eyes 0.155, least width just behind eyes 0.146, greatest width across cheeks 0.149, least width near base 0.142; pronotum, median length 0.117, width 0.197; mesothorax, greatest width 0.263; metathorax, greatest width 0.246; fore wings, length 0.742, width at middle 0.036; abdomen, greatest width 0.322.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	20	40	53	45	41	44	13	14
Width ( $\mu$ ):	24	27	18	18	17	16	7	5

Total length of antenna 0.270 mm.

♂ (macropterous).—Length about 0.78 mm. (distended, 0.95 mm.). Color and structure almost as in female, excepting that segment VII of the abdomen is pale like VI; abdomen more slender than in female, normal to the genus.

Described from 21 ♀♀ and 4 ♂♂, all taken by the author at Galice, Oregon, July 24, 1927, on stems and leaves of a species of *Chrysothamus* growing in the flood plain of the Rogue River.

The coloration of the abdomen, wings, and head distinguish this species at once from all members of its genus, with the exception of *S. moultoni* Jones, from which it differs conspicuously in the possession of an unbroken pronotal blotch, the pale scale at the base of the fore wings, the narrower and less finely striate

mesonotum, and the much shorter intermediate antennal segments.

The color of this species is highly adaptive. The delicate dorsal sculpture and the microtrichia on the abdomen and wings eliminate all shine, while the internal pigmentation, showing through the paler portions of the integument, aid in giving the insect a general grayish color which renders it almost invisible against the stems of the plant on which it lives. The color description given above can best be followed by supplementing, or at times replacing, the light from the substage mirror of the microscope by an intense, direct illumination from above.

**Sericothrips opuntiae** sp. nov. (Fig. 1, a, b).

♀ (macropterous).—Length about 1.0 mm. (distended, about 1.2 mm.). COLOR pale whitish yellow, with indistinct brown markings; pronotum with the usual gray-brown median blotch fragmented, consisting of a more or less continuous transverse band whose ends involve the two pairs of small foveæ on each side (this band arcuate posteriorly at middle), and two pairs of obscure spots which occupy the two pairs of posterior foveæ, the anterior pair of spots larger, transverse, and often more or less divided into two; mesothorax obscurely shaded with gray at sides and front margin of mesoscutum, and with the axillary sclerites and the tips of tegulæ darker; metanotum with a pair of obscure gray-brown spots; abdomen with the usual conspicuous dark brown transverse line at base of terga II–VII, behind which, at either end, is a brown spot; pleurites shaded with brown, and a pair of small round spots at sides of sterna III–VI or III–VII; legs concolorous with lighter portions of body, little or not shaded with gray; fore wings with grayish-yellow cast, with a slightly darker cloud in the area of the three subbasal setæ and another cloud at basal third, its setæ brown; antennæ rather pale, major setæ brown, segment I nearly colorless, II yellowish and slightly darker, III yellowish, with narrowed basal portion beyond pedicel and distal fourth gray-brown, IV and V similar, but with pedicels and distal fourth brown, the former segment a trifle darker at apex than the latter, VI–VIII gray-brown, VI usually paler toward base; ocellar pigmentation red.

HEAD (Fig. 1, a) much broader across eyes than elsewhere, cheeks slightly rounded and distinctly converging to base, occipital line indistinct, pale, interrupted at middle, no transverse groove behind eyes; entire dorsum of head faintly cross-striate; setæ as usual in the genus and as described above for *S. chrysothamni*, the postocellar pair only 23  $\mu$ , the lower lateral pair on cheeks not visible from above. EYES prominent, protruding, pilose, extending to within 11  $\mu$  of the occipital line, their dorsal length (when the head is horizontal and not tipped downward) about 76  $\mu$ , their width 51  $\mu$ , least interval 61  $\mu$ , ventral width 42  $\mu$ , ventral interval 79  $\mu$ . OCELLI about 12  $\mu$  in diameter, nearly equidistant, about 20  $\mu$  apart. ANTENNÆ (Fig. 1, b)



about 1.6 times as long as width of head across eyes, segments formed as usual in this section of the genus; III about  $54\mu$ , IV about  $46\mu$ , each with a short, U-shaped sense-cone, that on III about  $23\mu$  long; VI not pedicellate; inner seta on dorsum of antennal segment II subequal to outer seta and unusually short ( $14\mu$ ), distal dorsal setae on III and IV brown, likewise short ( $19\mu$ ), barely surpassing apex of segments. MOUTH-CONE extending about to base of prosternum, its length (measured from base of labrum) about  $110\mu$ , the three segments of the maxillary palpus 20, 11, and  $17\mu$ , respectively.

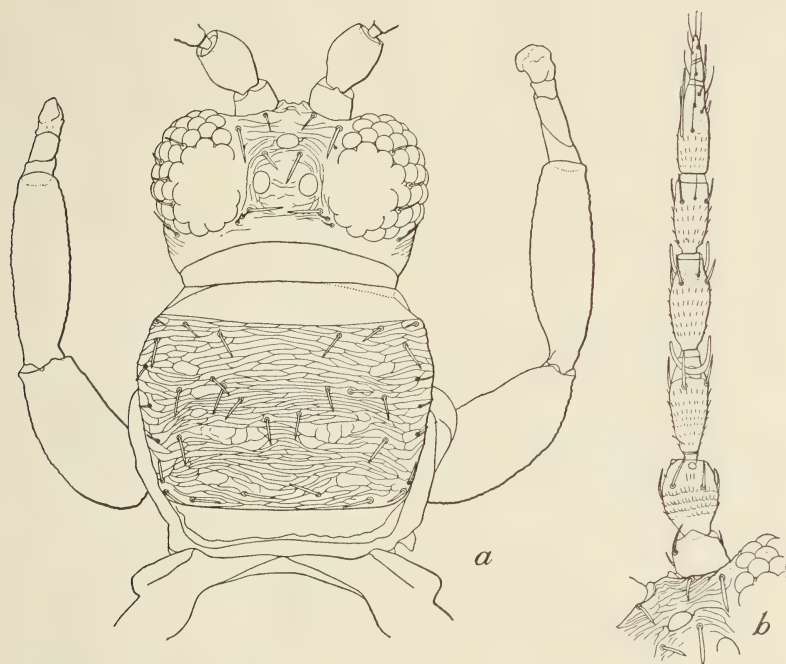


Figure 1. *Sericothrips opuntiae* sp. nov., ♀, paratype. *a*, head and prothorax (all setae omitted from appendages); *b*, right antenna.

PROTHORAX (Fig. 1, *a*) with the pronotum about 0.66 as long as width of head across eyes and about 1.7 times as wide as long, the transverse anastomosing lines quite distinct even in specimens not treated with caustic, somewhat more closely spaced in the area of the pronotal blotch than in front of it, scarcely tending toward reticulation; setae of normal arrangement, the pair at posterior angles pale yellowish like the others, but closely appressed to pronotum and only  $20\mu$  in length. MESONOTAL PLATE about  $135\mu$  in extreme width, simply and moderately closely striate (about 6 transverse striae in  $10\mu$ ). FORE WINGS short ( $574\mu$ ), scarcely 15 times as long as width

at middle ( $40\ \mu$ ); costal margin with about 25 setæ which are shorter than or about equal to their intervals, those at middle of wing only  $20\ \mu$ ; longitudinal vein with a basal group of three followed by about 19, all of them particularly short ( $18\ \mu$ ) and scarcely half as long as width of wing at middle; no additional seta near tip of wing, between and behind the last two on longitudinal vein. LEGS normal.

ABDOMEN thoroughly typical; pubescence indistinct, completely lacking from median portions of terga I-V, sparse across the base of VI; comb complete only on posterior margins of VII and VIII; major abdominal setæ yellow on distal segments, more brownish on basal ones.

Measurements of ♀ (paratype), in mm.: Length about 0.97 (distended, 1.24); head, median length in front of occipital line 0.083, width across eyes 0.164, greatest width across cheeks 0.150, least width near base 0.133; pronotum, median length 0.109, width 0.181; mesothorax, greatest width 0.210; metathorax, greatest width 0.209; abdomen, greatest width (at segment IV) 0.281.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	20	38	54	46	37	45	11	13
Width ( $\mu$ ):	28	28	21	20	18	17	7	5

Total length of antenna 0.264 mm.

♂ (macropterous).—Length about 0.8 mm. (distended, 0.94 mm.). Color and structure essentially as in female, the abdomen more slender, normal to the genus.

Described from 12 ♀♀ and 6 ♂♂, all taken by the writer on a large tree-like cactus belonging to the genus *Opuntia* (Dr. Paul C. Standley, det.), near the Indian village of Comobabi, on the Papago Indian Reservation in Arizona, August 28, 1927 [Hood No. 852].

The absence of setæ from the median portions of the basal abdominal terga, together with the coloration, the moderately slender legs, and the lack of additional setæ on the fore wing behind the distal end of the longitudinal vein, separate this species from all others in the genus with the exception only of *apicalis* and the three new ones described below. In all four of these last, however, the inner seta near the apex of the second antennal segment is much longer, stronger, and darker than the relatively indistinct outer seta, instead of subequal to it. In *apicalis*, too, the distal setæ on antennal segments III and IV distinctly surpass the apices of the segments and measure  $23\text{--}33\ \mu$  in comparison with  $19\ \mu$  in the present species; the seta near the posterior angle of the pronotum is more than  $50\ \mu$  in length, instead of  $20\ \mu$ , and outstanding, rather than closely appressed; and the wing-setæ are much

stronger, those of the costal series at middle of wing being about  $47\ \mu$  and longer than the width of the wing at this point, in comparison with a length of about  $20\ \mu$ —which is only half the width of the wing—in *opuntiae*.

**Sericothrips collaris** sp. nov.

♀ (macropterous).—Length about 1.0 mm. (distended, about 1.12 mm.). COLOR straw yellow (more whitish by reflected light), with obscure, dark, gray-brown markings consisting of a spot occupying each pronotal fovea (sometimes very indistinct), a spot near each lateral angle of mesoscutum (these often more or less connected by a spot on anterior margin of mesoscutum), a pair of larger spots on metascutum, and a dark line across bases of terga II–VII, the lines on III–VII each with a small rounded spot behind each end; legs concolorous with body; fore wings pale yellowish, nearly colorless, with a slight brown cloud on longitudinal vein at the origin of its two most basal setæ and a second obscure cloud between vein and poster margin of wing just beyond scale, setæ all dark and conspicuous; antennæ with segments I and II yellowish and nearly concolorous with body, II distinctly shaded with gray, III–VIII more grayish but only slightly darker, III with an indistinct gray-brown cloud in narrow portion just beyond pedicel and distinctly gray-brown across apex, IV with pedicel concolorous with apex of III and its own apex shaded like that of III but a trifle more darkly, V colored like IV but not so darkly shaded at apex, VI–VIII nearly uniform gray brown; ocellar pigmentation yellow (slightly brownish).

HEAD broader across eyes than elsewhere and nearly twice as wide as length to occipital line, cheeks slightly rounded and converging posteriorly; dorsum of head faintly cross-striate in occipital region and cheeks (but not elsewhere), the cheeks just visibly serrulate; setæ as usual in the genus and as described above for *S. chrysothamni*, the third or interocellar pair located well within the ocellar triangle, the postocellars only  $24\ \mu$  long, and the outer postocular pair nearly on the profile of the cheeks, with the usual cheek-seta in front of it and ventro-lateral in position. EYES not as prominent as usual in the genus, less protruding, pilose, about  $16\ \mu$  from occipital line, their dorsal length  $56\ \mu$ , dorsal width  $40\ \mu$ , dorsal interval  $57\ \mu$ , ventral width  $36\ \mu$ , ventral interval  $66\ \mu$ . OCELLI about  $13\ \mu$  in diameter, the posterior pair about  $21\ \mu$  apart and  $18\ \mu$  from median ocellus. ANTENNÆ about 1.6 times as long as width of head across eyes, segments formed about as usual in this section of the genus, but more stout; III  $43\ \mu$ , IV  $34\ \mu$  and only twice as long as wide, each with a short, biramous sense-cone which is more in the form of a broad V than a U, that on IV with its median axis about  $13\ \mu$  long; VI not pedicellate; major setæ on segments II–V short, stout, and brown, the inner dorsal on III about  $20\ \mu$  only, the inner one on II much larger than the outer. Mouth-cone extending about to base of prosternum, its length (measured from base of labrum) about  $126\ \mu$ , the three segments of the maxillary palpus unusually short, measuring 14, 13, and  $14\ \mu$ , respectively.

PROTHORAX large, the pronotum about 0.82 as long as width of head across eyes and 1.5 times as wide as long, the transverse anastomosing lines pale, not prominent, not more closely spaced in the area of the pronotal blotch (about 7 of them in  $20\ \mu$ ), nowhere tending toward reticulation, unusual in that those near the margins are concentric, with the ones at the lateral margins thus longitudinal (!); setæ rather short and heavy, light brownish yellow, two outstanding pairs at posterior angles, the inner ones about  $53\ \mu$ , the outer  $21\ \mu$ . MESONOTUM faintly cross-striate. FORE WINGS about 16 times as long as width at middle, slender and pointed at tip; costal margin with about 23 conspicuous, brown setæ which taper only slightly and are rather abruptly pointed at apex, those at middle of wing about  $56\ \mu$ ; longitudinal vein with 17-21 similar setæ (no basal group of 3), those at middle of wing about  $47\ \mu$ ; no additional setæ near tip of wing behind vein. Legs normal.

ABDOMEN thoroughly typical; pubescence minute, close, and very indistinct, lacking from median portions of terga I-VIII and from all of IX and X; comb complete only on posterior margin of VIII (where the teeth are minute), irregular on VII; lateral setæ and those on X all brown, dorsal ones yellow.

Measurements of ♀ (holotype), in mm.: Length about 0.98 (distended, 1.12); head, median length to occipital line 0.073, width across eyes 0.138, greatest width across cheeks 0.136, least width near base 0.126; pronotum, median length 0.113, width 0.168; mesothorax, greatest width 0.242; metathorax, greatest width 0.232; fore wings, length 0.630, width at middle 0.040; abdomen, greatest width (at segment IV) 0.290.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	16	35	43	34	31	41	12	13
Width ( $\mu$ ):	21	25	17	17	16	15	6	4

Total length of antenna 0.225 mm.

♂ (macropterous).—Length about 0.67 mm. (distended, 0.75 mm.). Color and essential structure almost as in female; abdomen more slender.

Described from 10 ♀♀ and 1 ♂, all taken by the author at Wickenburg, Arizona, August 25, 1927, on a plant which Dr. Paul C. Standley has determined as "*Hymenoclea monogyra*?" [Hood No. 881].

*S. opuntiae*, described immediately above, and *S. ctenogastris*, described below, are undoubtedly the closest known allies of the present species. From the former it differs most notably in the much longer setæ on the wings and at the posterior angles of the pronotum, in the unequal lengths of the two dorsal setæ near the apex of the second antennal segment, in the very short and stout fourth antennal segment, and in a character possessed by no other species of the genus excepting the very different *S. sensillis*,—



namely, the longitudinal arrangement of the striae at the extreme sides of the pronotum. From *S. ctenogastris*, the only other species excepting *sensillis* with the fourth antennal segment as short, it is best distinguished by the distinct dorsal markings and the complete absence of any comb on the posterior margins of the fifth and sixth abdominal terga. *S. sensillis*, though resembling the present species in its pronotal sculpture, is unique in having the sense-cones on the third and fourth antennal segments simple and fingerlike, rather than V- or U-shaped; and it differs, too, in that the pronotal and wing setae are much shorter.

***Sericothrips ctenogastris* sp. nov.**

♀ (macropterous).—Length about 1.0 mm. (distended, 1.1 mm.). COLOR uniform straw-yellow (more whitish by reflected light), without darker markings of any sort; legs concolorous with body; fore wings nearly colorless, with two barely perceptible clouds, one of them at the origin of the two most basal setae on the longitudinal vein, the other between vein and posterior margin of wing just beyond scale; setae on wings all moderately dark, yellowish brown, and conspicuous; antennae with segments I and II yellowish and concolorous with body, II scarcely shaded with gray, III–VIII pale and hardly darker than I and II, III with an indistinct gray-brown cloud in narrow portion just beyond pedicel and narrowly and indistinctly gray-brown at extreme apex, IV with its very short pedicel concolorous with apex of III and its own apex shaded like that of III but somewhat more broadly and darkly, V colored like IV but not so dark at apex, VI–VIII nearly uniform yellowish gray; ocellar pigmentation yellow.

HEAD broader across eyes than elsewhere and about 1.7 times as wide as length to occipital line, cheeks rounded to eyes, nearly straight and converging posteriorly; head faintly cross-striate in occipital region and on cheeks (but not elsewhere), the cheeks just visibly serrulate; setae as usual in the genus and as described above for *S. chrysothamni*, the third or interocellar pair located on or close to a line tangent to the outer edges of the median and posterior ocelli, the postocellars about  $27\mu$  long, and the outer postocular pair nearly on the profile of the cheeks, with the usual cheek-seta beneath it and ventro-lateral in position. EYES not as prominent as usual in the genus, less protruding, pilose, about  $15\mu$  from occipital line, their dorsal length about  $60\mu$ , dorsal width  $40\mu$ , dorsal interval  $53\mu$ . OCELLI about  $13\mu$  in diameter, the posterior pair about  $25\mu$  apart and  $17\mu$  from median ocellus. ANTENNAE about 1.6 times as long as width of head across eyes, segments formed about as usual in this section of the genus, but more stout; III  $40\mu$ , IV  $30\mu$  and distinctly less than twice as long as wide, each with a short biramous sense-cone which is more in the form of a broad V than a U, that on IV with its median axis about  $12\mu$  long; VI not pedicellate; major setae on segments III–V short, stout, and

brown, the inner dorsal on III about  $17\ \mu$  long, the inner one on II  $21\text{--}24\ \mu$ , much larger than the outer, and more yellowish than those on III. Mouth-cone (measured from base of labrum) about  $125\ \mu$ , the three segments of the maxillary palpus unusually short, measuring 14, 13, and  $14\ \mu$ , respectively.

PROTHORAX large, the pronotum about 0.84 as long as width of head across eyes and about 1.5 times as wide as long, the transverse anastomosing lines pale, not prominent, not more closely spaced in the central portion than elsewhere (about 9 of them in  $20\ \mu$ ), nowhere tending toward reticulation, those near lateral margins not longitudinal; setæ strong but not particularly short, light brownish yellow in color, two outstanding pairs at posterior angles, the inner ones about  $57\ \mu$ , the outer  $31\ \mu$ . MESONOTUM very faintly cross-striate. FORE WINGS about 17 times as long as width at middle, slender and pointed at tip; costal margin with 19–22 conspicuous yellowish brown setæ which taper only slightly and are rather abruptly pointed at apex, those at middle of wing about  $52\ \mu$ ; longitudinal vein usually with either 17 or 18 similar setæ, of which a basal group of three is usually a little isolated from the others, those at middle of wing about  $48\ \mu$ ; no additional setæ near tip of wing behind vein. LEGS normal.

ABDOMEN with pubescence minute, close, and very indistinct, lacking from median portions of terga I–VIII and almost certainly also from IX and X; comb complete on posterior margin of terga VI–VIII (!), occasionally nearly or quite complete on V; lateral setæ and those on X all brown, dorsal ones yellow.

Measurements of ♀ (holotype), in mm.; Length about 0.97 (distended, 1.09); head, median length to occipital line 0.078, width across eyes 0.133, greatest width across cheeks 0.132, least width near base 0.125; pronotum, median length 0.112, width 0.170; mesothorax, greatest width 0.228, metathorax, greatest width 0.224; fore wings, length 0.616, width at middle 0.035; abdomen, greatest width (at segment IV) 0.259.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	17	35	40	30	31	40	8	12
Width ( $\mu$ ):	21	26	17	18	17	15	6	4

Total length of antenna 0.213 mm.

♂ (macropterous).—Length about 0.65 mm. (distended, 0.79 mm.). Color and essential structure almost as in female; comb complete on abdominal terga VI–VIII; abdomen slender.

Described from 9 ♀♀ and 1 ♂, all taken by the author on *Hymenoclea monogyra* Torr. and Gray (determined by Dr. Paul C. Standley), near Phoenix, Arizona, August 26, 1927 [Hood No. 884].

The affinities of this species were treated above, under the

description of *S. collaris*. With that species and *S. sensillis*, described below, it forms a natural group characterized by the short and stout antennal segments. The three complete combs on the sixth, seventh, and eighth abdominal segments distinguish it readily from both.

***Sericothrips sensillis* sp. nov.**

♀ (macropterous).—Length about 0.84 mm. (distended, 1.01 mm. COLOR uniform straw-yellow (more whitish by reflected light), without darker markings of any sort excepting a dark transverse line at the bases of terga III–VII; legs concolorous with body; fore wings nearly colorless, their setæ all moderately dark, yellowish brown, and conspicuous; antennæ with segments I and II yellowish and concolorous with body, II scarcely shaded with gray, III–VIII pale and hardly darker than I and II, III with an indistinct gray-brown cloud in narrow portion just beyond pedicel and narrowly gray-brown at extreme apex, IV with its very short pedicel concolorous with apex of III and its own apex shaded like that of III but somewhat more broadly, V colored like IV but not so dark at apex, VI–VIII nearly uniform yellowish gray; ocellar pigmentation yellow.

HEAD somewhat broader across eyes than across cheeks and about 1.4 times as wide as length to occipital line, cheeks rounded to eyes, nearly straight and converging posteriorly; dorsum of head exceedingly faintly cross-striate in occipital region only, the cheeks not serrulate; setæ as usual in the genus and as described above for *S. chrysothamni*, the third or interocellar pair located on or close to a line tangent to the outer edges of the median and posterior ocelli, the postocellars only 16  $\mu$  long, and the outer postocular pair nearly on the profile of the cheeks, with the usual cheek-seta beneath and anterior to it, and ventro-lateral in position. EYES not as prominent as usual in the genus, less protruding, pilose, about 13  $\mu$  from occipital line, their dorsal length about 56  $\mu$ , dorsal width 34  $\mu$ , dorsal interval 50  $\mu$ . OCELLI about 12  $\mu$  in diameter, the posterior pair about 20  $\mu$  apart and 15  $\mu$  from median ocellus. ANTENNÆ about 1.6 times as long as width of head across eyes, segments formed about as usual in this section of the genus, but more stout; III only 33  $\mu$ , IV only 25  $\mu$  and distinctly less than twice as long as wide, each with a simple, short, stout, finger-shaped sense-cone; VI not pedicellate; major setæ on segments III–V short, stout, and brown, the inner dorsal on III only 11  $\mu$  long, the inner one on II about 15  $\mu$ , much larger and darker than the outer, and about concolorous with those on III. MOUTH-CONE (measured from base of labrum) about 111  $\mu$ .

PROTHORAX about 0.8 as long as width of head across eyes and about 1.5 times as wide as long, the transverse anastomosing lines pale, not prominent, not more closely spaced in the central portion than elsewhere (9–10 of them in 20  $\mu$ ), nowhere tending toward reticulation, unusual in that those near the margins are concentric, with the ones at the extreme lateral margins thus

longitudinal (!); setæ short and heavy, the two outstanding pairs at posterior angles brown and darker than those on disc, the inner ones  $34\mu$ , the outer  $17\mu$ . MESONOTUM very faintly cross-striate. FORE WINGS about 14 times as long as width at middle, slender and pointed at tips; costal margin with 20-21 conspicuous yellowish brown setæ which taper only slightly and are rather abruptly pointed at apex, those at middle of wing about  $33\mu$ ; longitudinal vein with 17 similar setæ, of which a basal group of three is rather distinctly separated from the others, those at middle of wing about  $32\mu$ ; no additional setæ near tip of wing behind vein. LEGS normal.

ABDOMEN thoroughly typical; pubescence minute, close, and very indistinct, lacking from median portions of terga I-VIII and from all of IX and X; comb complete on posterior margins of VII and VIII, a broad median gap in the comb on VI and all preceding terga; lateral setæ and those on X all brown, dorsal ones yellow.

Measurements of ♀ (holotype), in mm.: Length about 0.84 (distended, 1.01); head, median length to occipital line 0.084, width across eyes 0.118, greatest width across cheeks 0.114, least width near base 0.107; pronotum, median length 0.093, width 0.138; mesothorax, greatest width 0.179; metathorax, greatest width 0.177; fore wings, length 0.498, width at middle 0.035; abdomen, greatest width (at segment IV) 0.206.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	16	33	33	25	29	36	8	12
Width ( $\mu$ ):	21	24	16	15	16	14	6	4

Total length of antenna 0.192 mm.

Described from 1 ♀, taken by the author on *Isocoma venata* var. *arguta* Jeps. (determined by Dr. Paul C. Standley), at Quijotoa, Arizona, August 28, 1927 [Hood No. 903].

Remarkable, indeed, is the character of the antennal sensoria, causing one perhaps to doubt the correctness of the assignment of the species to the genus in which it has been placed; and yet in no other respect does the insect show the slightest departure from the fundamental structure of the genus; nor is it, save in this one feature, more different from *collaris* and *ctenogastris* than are these two from each other. Were it not for the differently proportioned antennal segments, the shorter pronotal and wing setæ, the more closely striate pronotum, and the smaller size, the author would have been inclined to consider it possibly a mutation of *S. collaris* and to defer its description indefinitely; but the additional light which it throws upon what he considers the superficiality of any classification based upon antennal sense-organs has seemed to warrant its naming at the present time.



**Trichothrips xanthocephalus** sp. nov.

♀ (brachypterous).—Length about 1.3 mm. (very slightly distended, 1.5 mm.). Head lemon-yellow; thorax and abdomen brown, the abdomen concolorous with prothorax in its basal portion, shading to yellow in segment VII, and with VIII–X bright yellow, the pterothorax appreciably paler than prothorax and base of abdomen, the tube with a narrow ring of gray at tip; legs concolorous with head, middle and hind femora very lightly shaded with brown; antennæ with segments I and II yellowish in color, somewhat darker than head because of a light brown shading, III–VIII uniform blackish brown, with only the pedicel of III yellow; fat-body pigmentation dull red.

HEAD about 1.25 times as long as greatest width, broadest at about basal third, cheeks rounded to base and slightly tapering in anterior portion, abruptly rounded to the small eyes, the width across the latter distinctly less than the least width of head near base and about 0.87 the greatest width; dorsum of head, as seen from the side, somewhat elevated in the occipital region; vertex not produced or overhanging, its apex on a line with front margin of eyes, its surface lightly subreticulate; posterior portion of cheeks with delicate, pale, anastomosing lines which enroach onto the dorsum of head in occipital region; postocular setæ pale yellowish, about  $81\mu$  long,  $120\mu$  apart, and  $23\mu$  from posterior margin of eyes, their tips broadly rounded, rather than pointed or dilated; setæ on cheeks minute, pale, and pointed; dorso-cephalic setæ minute,  $71\mu$  apart and  $33\mu$  behind postoculars. EYES very small, less than one-fourth the length of head and about two-thirds as wide as their interval, measuring as follows in  $\mu$ : length 45, width 39, interval 60. OCELLI small, the median one on the same line as front margin of eyes, one of the posterior ocelli wanting in the holotype. ANTENNÆ twice the length of head, formed almost exactly as in *T. angusticeps*, segment VIII lanceolate and pedicellate (see Hood, Bull. Ill. State Lab. Nat. Hist., 8(2): 367, Fig. 4, b); sense-cones on inner (outer) surfaces as follows: III 1(2), IV 1(2), V 1( $1^{+1}$ ), VI 1( $1^{+1}$ ), VII 1 dorsal; all antennal setæ long and pointed. MOUTH-CONE extending well past middle of prosternum, its length beyond dorsal margin of head about  $118\mu$ .

PROTHORAX along median dorsal line of pronotum about 0.72 as long as head and (inclusive of coxæ) about 2.1 times as wide as long, without median thickening, without trace of sculpture except for about two faint striæ at posterior margin, epimeron not fused with pronotum; major setæ all present, long, yellow in color, with broadly rounded or slightly dilated tips, their lengths as follows in  $\mu$ : antero-marginals 39, antero-angulars 53, midlaterals 60, epimerals 88, postero-marginals 87, coxals 73. PTEROTHORAX very slightly narrower than width of prothorax inclusive of coxæ. WINGS about attaining base of abdomen, the fore pair with two long setæ which are about comparable with antero-marginals. LEGS thoroughly typical, the fore tarsus with a very minute tooth.

ABDOMEN of normal form and structure, broadest at segment III, where

it is much wider than pterothorax, its dorsal surface free of sculpture excepting for the usual transverse subbasal line across each of terga II–VIII and faint, anastomosing, minutely asperate lines which form an obscure subreticulation at sides of segments and which are continued across the dorsal surface of the more basal segments; tube (segment X only) about 0.73 the length of head and about 1.8 times as long as its own greatest subbasal width, the last distinctly more than twice the distal width, the sides almost perfectly straight; abdominal setæ long, slender, all pointed excepting the dorso-lateral pair on VIII which is rounded at tip and  $74\mu$  long, all yellow excepting the terminal ones, which are brown; VII with the lateral setæ  $156\mu$ , VIII with these  $117\mu$ , IX with lateral and dorsal setæ subequal and about  $183\mu$ , longest terminal setæ  $170\mu$ .

Measurements of ♀ (holotype), in mm.: Length about 1.33 (very slightly distended, 1.46); head, length 0.198, width across eyes 0.138, greatest width across cheeks 0.159, least width near base 0.147, length of head in front of eyes 0.028; prothorax, median length of pronotum 0.142, greatest width (inclusive of coxae) 0.298; mesothorax, greatest width 0.295; abdomen, greatest width 0.358; tube (segment X only), length 0.145, greatest subbasal width 0.080, least apical width 0.037.

Antennal segments:	1	2	3	4	5	6	7	8
Length ( $\mu$ ):	40	50	52	50	52	51	50	50
Width ( $\mu$ ):	44	33	35	33	31	27	23	15
Total length of antenna 0.395 mm.								

*Type*.—♀; Tallulah, Louisiana. October 4, 1934. (Dr. J. W. Folsom; "in humus").

*T. americanus* and *T. angusticeps* are the only other North American species known to me which have the eighth antennal segment pedicellate and the fourth segment with one sense-cone on the inner and two on the outer surface. The former of these has the head much shorter and all the major setæ pointed, while the latter—to which it is indeed closely allied—has both the head and tube much shorter and the dorso-lateral pair of setæ on abdominal terga I–VII distinctly knobbed. *T. angusticeps* differs, too, in coloration, its head, legs, and tip of abdomen being distinctly brownish instead of bright lemon-yellow.

***Diopsothrips louisianæ* sp. nov.**

♀ (apterous).—Length about 1.4 mm. (rather fully distended, 1.85 mm.). General color brown, with head and pterothorax largely golden yellow, the head with front and vertex brown and with a faint brown dorsal cloud extending to near base, the pterothorax shaded with brown along anterior and lateral margins, the abdomen somewhat paler in the four basal segments, tube bright

reddish brown, with its extreme tip black; legs largely yellow, with fore femora shaded with brown basally, and middle and hind femora shaded with brown along most of outer surface; antennæ with segments I, II and about basal third of III golden yellow, the remainder of III shading to light blackish brown in apical half or more, IV-VII uniform dark blackish brown; fat-body pigmentation scattered, its color orange-red by transmitted light, more (or quite) yellowish by reflected light.

HEAD nearly 1.1 times as long as greatest width, broadest shortly behind middle, the cheeks subparallel and rounded about equally to eyes and to a slightly broader basal collar, the width across eyes about 0.92 the greatest width and about equal to the least width in front of base; vertex full, rounded, but not overhanging, sloping abruptly to antennal bases, with a pair of strong, pointed, yellowish setæ,  $50\mu$  long and  $61\mu$  apart, laterad and caudad of median ocellus, the vertical pores situated close to inner margins of eyes and on a line just posterior to the setæ; a pair of minute pale setæ  $17\mu$  long and  $61\mu$  apart situated just in front of middle of eyes and about  $35\mu$  behind median ocellus; postoculars pointed, pale yellowish, about  $85\mu$  long and  $122\mu$  apart, arising about  $5\mu$  from posterior margin of eyes; dorso-cephalic setæ minute, about  $85\mu$  apart and  $73\mu$  from base of head; cheeks with four or five similar pairs of minute, pale, pointed setæ, one of which is directly laterad of the large posterior facet of eyes, one laterad of the postoculars, the others near middle of cheeks and somewhat more dorsal in position; dorsal surface of head perfectly smooth save for a very faint, pale subreticulation in posterior part of cheeks. EYES small in the apterous type, about 0.3 the length of the head, their length  $60\mu$ , interval approximately  $100\mu$ , composed of a few small ( $12\mu$ ) anterior facets and about three large posterior ones, the most caudad of which is the largest and about  $26\mu$  in diameter. OCELLI represented in the apterous type by the median one only, this  $16\mu$  in diameter and with its anterior margin about  $20\mu$  in advance of that of eyes. ANTENNÆ stout, 7-segmented, the last without trace of any cross-suture; sense-cones slender, pointed, and moderately long, disposed as follows on the inner (outer) surfaces: III 1(1), IV 2(2), V 1(1<sup>+</sup>), VI 1(0<sup>+</sup>), VII 1 dorsal; all antennal setæ long and pointed. MOUTH-CONE semicircularly rounded at tip, extending well past middle of prosternum, its length beyond dorsal margin of head about  $157\mu$ .

PROTHORAX along median dorsal line of pronotum 0.7 as long as head and (inclusive of coxæ) about 2.4 times as wide as long, without median thickening, without trace of sculpture except for about three dark, distinct, anastomosing striæ along extreme posterior margin, epimeron fused with pronotum posteriorly; all usual setæ present, yellow, nearly pointed, their lengths as follows, in  $\mu$ : antero-marginals 60, antero-angulars 40, midlaterals 73, epimerals 110 postero-marginals 90, coxals 53. MESONOTUM with parallel, somewhat anastomosing, faintly asperate, cross-striæ. METANOTUM with the striæ non-asperate and forming polygons over most of the surface. LEGS rather short and stout, the fore tarsus with a stout tooth which is nearly equilaterally triangular in form. WINGS completely wanting.

ABDOMEN heavy, but not broad, widest at segment IV, where its width is

about 1.1 times that of prothorax across coxæ; sterna IV-VII with their anterior margins slightly arched forward; dorsal surface free of sculpture excepting for the usual transverse subbasal line across terga III-VIII and distinct, dark, fine, anastomosing lines in all of tergum I and the basal two-thirds of tergum II, the sculpture of the former more distinct and nearly polygonal; tube (segment X only) 1.26 times the length of head, about 2.26 times as long as its own greatest (subbasal) width, and just three times as broad near base as at apex, the latter abruptly constricted, the sides of tube nearly parallel in about basal fourth and arcuately tapering to the apical constriction, its surface with three or four longitudinal ridges on each side and numerous colorless, slender, curved setæ; terminal setæ weak, brownish yellow basally, about  $83\ \mu$  long; setæ on IX yellow, moderately heavy, pointed, the dorsal pair  $204\ \mu$ , the lateral pair  $234\ \mu$ .

Measurements of ♀ (holotype), in mm.: Length about 1.43 (rather fully distended, 1.85); head, length 0.196, width across eyes 0.166, greatest width across cheeks 0.181, least width near base 0.168; prothorax, median length of pronotum 0.137, width (inclusive of coxæ) 0.333; mesothorax, greatest width 0.346; abdomen, greatest width 0.370; tube (segment X only), length 0.247, greatest subbasal width 0.109, least apical width 0.036.

Antennal segments:	1	2	3	4	5	6	7
Length ( $\mu$ ):	47	58	66	59	54	47	71
Width ( $\mu$ ):	46	37	37	39	37	33	28
Total length of antenna 0.402 mm.							

*Type*.—♀; Tallulah, Louisiana. April 10, 1934. (Dr. J. W. Folsom; "in humus").

The two other species of *Diopsothrips* are known only from Panama, and it has therefore seemed desirable to describe the present one in order to add the genus to the North American list, even though it must be made known from the apterous form. The much darker color of the abdomen of *louisianæ* should distinguish it readily from *flavus*, as should also the longer cephalic and pronotal setæ and the less constricted tube. The macropterous form should be largely, if not entirely brown, with the pterothorax if not the head, about concolorous with the abdomen; and its coloration should therefore agree more closely with that of *brunneus*. That species, however, has the third antennal segment uniform dark yellow, instead of largely blackish brown, and the segments beyond the third much paler than in *louisianæ*. It is also larger, with differently proportional antennal segments and tube, and the two pairs of setæ on the anterior margin of the pronotum are much shorter.



## A REMARKABLE CICADA FROM MEXICO AND OTHER NORTH AMERICAN SPECIES

BY WILLIAM T. DAVIS

STATEN ISLAND, N. Y.

In the Transactions, Maryland Academy of Sciences, 1892, page 169, P. R. Uhler characterized *Odopœa pæyi* Guérin, of Cuba: "the most remarkable of all the species yet discovered in the West Indies if not in all America." In 1920 Mr. Distant placed it in a separate genus (*Juanaria*) and commented upon its close resemblance to several African species. The insect is figured in this JOURNAL, March, 1928, plate 1.

While *pæyi* is remarkable among species of American cicadas, it possesses no structural characters not to be found among African species, whereas the Mexican cicada here described as *Tibicen curvispinosa* possesses the unique development of two rather conspicuous spines on abdominal segment nine not observed in any other species of *Tibicen* or in allied genera. It is possible that these spines function in connection with the uncus.

In some other, not very closely related cicadas, there are marginal appendages on the ninth abdominal segment. In the Central and South American genus *Carineta*, for instance, which, unlike *Tibicen*, has the tympana uncovered, there are a number of species that have a fold on the lower margin of segment nine often terminated with a spine of tooth, about or on which there are numerous hairs or bristles.

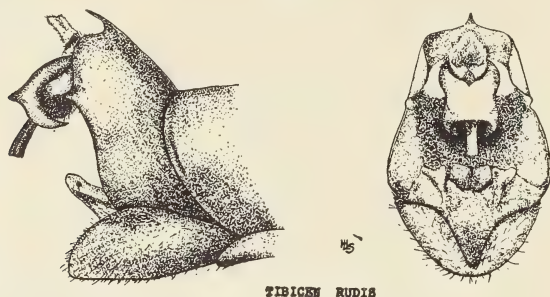
In addition to *Tibicen curvispinosa* I have received from many kind friends and institutions a number of cicadas, the records and descriptions of which follow, and, as usual, I am indebted to Mr. Hans L. Stecher for drawing the text figures.

### *Tibicen rudis* (Walker)

Francis Walker described *Fidicina rudis* from Orizaba, Mexico, collection M. Sallé, in "List of the Specimens of Homopterous Insects in the Collection of the British Museum. Supplement," 1858. The description is not very definite, but in "Biologia Centrali-Americana, Rhynchota-Homoptera" (1. p. 8 Tab. 2, fig.

20), Distant figures and briefly describes under the name of *Cicada rudis*, a specimen from the Vienna Museum. He gives the habitat as Mexico.

In the writer's collection there is a male from Mexico City, April, 1926 (Miss H. L. Ayres); 9 males and a female collected at Cuernavaca, Morelos, in May, four of them by M. Rodriguez, and two males labeled: "Mexico, May, 1930," that agree with Distant's figure in having the vertical pruinose spots at the side on abdominal segments 3 and 4 of nearly equal length.



TIBICEN RUDIS

In the American Museum of Natural History there is a male labeled "Mexico," and in the Museum of Comparative Zoology, Cambridge, Mass., there are three males from the western coast of Mexico that bear a striking resemblance to *Tibicen rudis* but which have surprisingly different genitalia.

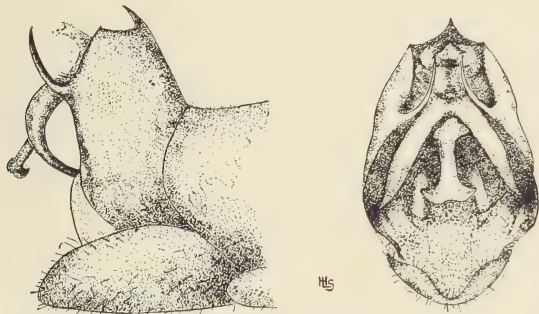
Both *rudis* and the allied species, here described as new, have the first cross vein of the fore wing as in the genus *Tibicen*, that is starting nearer to the base of the wing from radius 3 than in *Diceroprocta*, in which it starts at the lower central part of the first marginal area. Also, as in *Tibicen*, the last dorsal segment of the male terminates in a central spine and lacks the prominent lateral lobes found in *Diceroprocta*, and from which that genus derives its name.

***Tibicen curvispinosa* new species (Plate 3A, Fig. 1).**

Type male from Colima, Mexico. Collection, Museum of Comparative Zoology, Cambridge, Mass.

Resembles so closely in size and markings the colored figure given by Distant in Biol. Centr. Amer., Rhynch. Hom., tab. 2, fig. 20, that the illustration does well for both *rudis* and *curvispinosa*. In *curvispinosa* there is

a long, slim, upturned spine protruding backward from segment IX, not present in *rudis*, which has merely a low protuberance. The uncus in *curvispinosa* is deeply cleft with the resulting two claw-like extremities long and curved inward. In *rudis* the uncus has the much shorter claws curved toward each other and more suddenly bent inward. Also there is a prominent ridge across the uncus above the claws not present in *curvispinosa*. The opercula overlap, are slightly less broadly rounded at the extremities than in *rudis* and reach the third or fourth abdominal segment.



TIBICEN CURVISPINOSA

Body dark greenish-brown or chestnut colored with black markings. Head with an interrupted black stripe connecting the eyes. Pronotum with a central, oblong, pale spot touching the anterior margin; the grooves blackened, and a transverse black line along the anterior edge of the broadly, greenish-brown collar. Also a black spot each side at the end of the collar. Mesonotum with the usual four obconical spots reaching backward from the front margin, the inner pair shortest. The elevated  $\times$  dark greenish brown with a black spot in the depression anterior thereto, and a black stripe each side extending nearly to the fore wings. Tergum black with about the posterior half of each segment dark greenish brown. The type has a conspicuous pruinose spot each side at the base; one each side on segments 3, 4, 7 and 8. Beneath the body is pale and pruinose; the legs pale and the central broad stripe on the abdomen straw color. In the male from "Mexico" the pruinose spots at the base of the abdomen are small; there is a small spot each side on segments 3, 7 and 8. Wings with the venation dark brownish green, the basal cells of the fore wings clouded with black and dark green; basal membranes of both pair of wings blackish gray with a small and inconspicuous bright orange area at the base of each hind wing.

As has been indicated this color description will cover both *rudis* and *curvispinosa*.

MEASUREMENTS IN MILLIMETERS		Male Type
Length of body .....		37
Width of head across eyes .....		15

Expanse of fore wings .....	100
Greatest width of fore wing .....	15
Greatest length of operculum .....	8

Two additional males from Colima, Southwestern Mexico; a male from Nayarit, also on the west coast of Mexico and about 100 miles north of Colima, and the male from "Mexico" mentioned above, are the paratypes examined of this remarkable species.

Distant correctly states that *Tibicen rudis* (and his observation also applies to *curvispinosa*) "much resembles [in general form] the well-known European species *C. fraxini*" or *plebeja*, designated as the type of the genus *Tibicen* as at present understood.

In "Studies in Certain Cicada Species" (Entomological News, April, 1907), Smith and Grossbeck emphasize the importance of an examination of the male genitalia as a means of separating the species of cicadas, and as an example of a remarkable structure they show on Plate 3 the end of the abdomen of what is here described as *Tibicen curvispinosa*. They did not describe the species on account of lack of specimens.

***Tibicen nigroalbata* new species** (Plate 3A, Fig. 2).

Type female from Santa Cruz County, Arizona, August 15, 1935 (Prof. E. D. Ball) American Museum of Natural History.

Resembles both *Tibicen rudis* and *Tibicen curvispinosa*, but the front of the head is differently shaped and the tergum is shining black except for the pruinose spots. In *rudis* and *curvispinosa* the tergum is mainly chestnut-colored with the segments blackened along the base only.

Head shaped as figured and the abdomen broader at segment six than at base. In the female of *rudis* the sides are more parallel.

Head black, a transverse stripe extending from the rugæ nearly to the eyes; a spot on the front and an oblique stripe each side of the ocelli extending backward to the hind margin, chestnut-brown. Pronotum narrowly edged anteriorly with brown, a central oblong pale spot touching the anterior margin; the grooves blackened, and a conspicuous transverse black band along the anterior edge of the broadly brown collar. Also a black spot each side at the end of the collar. Mesonotum black, with the posterior margin, the cruciform elevation and a spot each side near the base of the wing, brown. The usual obconical areas are outlined at the sides with brown. Tergum shining black with conspicuous pruinose spots at sides, arranged as shown on the plate. Beneath the body is pale darker about the head and pruinose; the legs pale and the central broad stripe on the abdomen pale chestnut color. Wings with the venation dark, the basal cells of fore wings almost black, as well as the basal membranes of both pair of wings.



## MEASUREMENTS IN MILLIMETERS

	Female Type
Length of body .....	38
Width of head across eyes .....	15
Expanse of fore wings .....	102
Greatest width of fore wing .....	16

In writing of the specimen here described, Prof. Ball stated that it came from Atascosa Mountain, 24 miles (by road) northwest of Nogales in Santa Cruz County, Arizona, probably four or five miles from the Mexican border. "These big cicadas were singing everywhere in the oaks, but very difficult to get hold of. This female was purely accidental; I was beating the tree for tree-hoppers."

Twelve male and one female *rudis*, and five *curvispinosa* have been examined, none of which are black as in *nigroalbata*. In the "Transactions of the Maryland Academy of Sciences" (1892, page 154), P. R. Uhler states that *rudis*: "inhabits Eastern Mexico, and is much like a fragmentary specimen in my collection from Arizona."

***Tibicen paralleloides* Davis.**

This species was described and figured in the JOURNAL, N. Y. Entomological Society, for March, 1934, from a single male collected in the vicinity of Compostela, Nayarit, Mexico. A second male has been discovered in the collection of the American Museum of Natural History labeled "Mazatlan, Mexico." This is no doubt the coast town of Mazatlan about 175 miles northwest of Compostela. The same differences in length of rostrum and venation are noted between this specimen and the five *T. parallela* in the writer's collection, as recorded on page 41 of the original description.

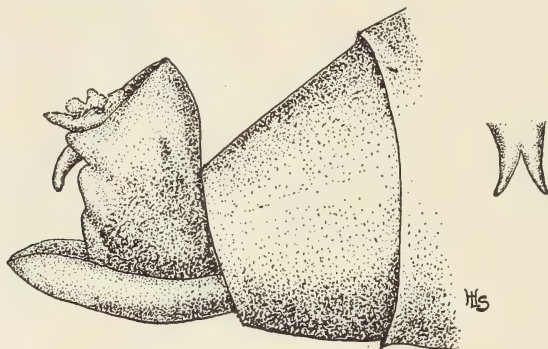
On August 18, 1935, Dr. R. H. Beamer and his companions collected eight males and one female *Tibicen parallela* in the Santa Rita Mountains, Arizona.

***Melampsalta texana* new species (Plate 3B, Fig. 6).**

Type male from 10 miles east of San Antonio, Texas, May 19, 1935 (Charles H. Gable, Jr.). Davis collection.

Resembles the pale green colored *Melampsalta kansa*, in having five long marginal areas in the hind wing instead of six, as in *M. calliope*, but differs

from both of them in having the dorsal tip of the abdominal segment IX rounded and not drawn out into a curved point. In *M. cameroni*, also from Texas, there are five short marginal areas in the hind wing; the dorsal tip of segment IX is rounded, and it is broad instead of narrow across the widely open tympanal areas of the abdomen. The opercula are much larger and rounded out than in *texana*. In *cameroni* the marginal areas of the fore wing are shorter than the ulnar areas immediately adjoining them, while in *texana* the marginal areas are longer. In *texana* the head is narrow and the supra-antennal plates are nearly as in *cameroni*, and not protruding as in *kansa*. It is less hairy beneath than *cameroni*.



### MELAMPUS TEXANA

General color of upper surface of body dark green; head black, front green; pronotum green, grooves narrowly black; mesonotum green with four obconical dark marks, the inner pair about one third as long as the outer pair. Hind margin of the metanotum green. Both pairs of wings clear; basal membranes almost white. Tergum green, the exposed timbals darker. Beneath the front green with black surrounding the transverse rugae. Legs pale, darker at base, and with claws and spines fuscous. Opercula green; abdomen green with the usual dark spot centrally at the base.

#### MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body .....	12
Width of head across eyes .....	3
Expanse of fore wings .....	27
Greatest width of fore wing .....	5.5

The type is the only specimen so far examined, but the structural characters are so distinct that it may be separated as a species.

**Okanagana magnifica** Davis, and the Development of a Supernumerary Vein.

A very unusual condition exists in many individuals of this large species, irrespective of the locality from whence they come. It is the development of a branch or indications of a branch vein extending from vein  $Cu_1$  into the 8th marginal area of the fore wing. In its greatest development this supernumerary vein extends nearly across the 8th marginal area and then either turns upward or downward. In its least development it consists of a mere thickened node at about the central part of vein  $Cu_1$ . When it exists, the position of the vein, or its indication, has considerable regularity.

Three hundred and four specimens of *magnifica* in the writer's collection from Arizona, New Mexico and Colorado have been examined, and the supernumerary vein has been found more or less developed in 77 individuals, or about one fourth of the number. A great many *Okanagana* of other species have been examined, between one and two thousand in all, and only in a single male of *annulata* has an indication of such a supernumerary vein been found. There are about fifty species in the genus in North America, as well as many cicadas of other genera, that get on very well without developing a supernumerary vein from  $Cu_1$ .

**Okanagana formosa** Davis.

The type and allotype of this species came from Coal Creek, Iron County, Utah, June 27, 1919, and were described and figured in this JOURNAL for June, 1926. In 1930 Dr. John W. Sugden, of Salt Lake City, sent me for examination a female of this species collected in 1929 in Zion Park, Washington County, Utah, and in the collection of the U. S. National Museum there is a male from Helper, Carbon County, Utah, August 4, 1899. These specimens are alike and may be told from *cruentifera* by having the hind margin of the pronotum, and sometimes the sides as well, orange; in *cruentifera* the entire pronotum is black. There are other less conspicuous differences as well as the shape of the uncus.

**Okanagana aurora** new species (Plate 3A, Figs. 3 & 4).

Type male and allotype female, Mammoth, Mono County (near Inyo County line), California (Dr. J. A. Comstock). Davis collection.

Resembles *Okanagana cruentifera*, but smaller and with a narrower head the front of which is considerably produced. It more closely resembles the little known *Okanagana formosa* from Iron County, Utah, described and figured in this JOURNAL, June, 1926, but the color arrangement is different and as in *cruentifera* it is more hairy both above and beneath than *formosa*.

Head narrower than pronotum at anterior angles with the grooves as in *cruentifera* and *formosa*. Median sulcus of the front well defined, with the sides more parallel near the top but separated below as in *cruentifera*. Last ventral segment with the sides not quite as converging as in *cruentifera* and *formosa*, and more broadly rounded at the extremity. Uncus black, and as figured. The last ventral segment of the allotype is deeply notched centrally with an indication of an inner notch which is more pronounced in the female paratype.

Fore wings shaped as in *formosa* and *cruentifera*. The venation, including nearly the entire costal margin, a bright orange except about the marginal areas. Basal cell of the fore wings black centrally, with a small black spot below. Both pairs of wings at base, as well as the anal membranes, bright orange, but not red as in *cruentifera* and *formosa*.



OKANAGANA AURORA

Type entirely black above with a small orange spot each side on the mesonotum at base of the wings, and also the hind margin narrowly edged with orange. Metanotum narrowly margined posteriorly with bright orange. Segments 8 and 9 of the tergum margined posteriorly with orange, and very briefly and narrowly at the sides near the lower part of the abdomen. The female paratype is black above like the type, but the allotype in addition to the orange spot of the type, has a pale spot above each antenna, the pronotum very narrowly pale on the margins, seen when magnified, and two small orange spots at the anterior extremities of the cruciform elevation. Segments 8 and 9 are broadly margined posteriorly with bright orange. Beneath black; legs nearly entirely orange, each abdominal segment very narrowly margined posteriorly with orange except the last which is broadly margined. Valve orange clouded at the base and sides.



## MEASUREMENTS IN MILLIMETERS

	Male Type	Female Allotype
Length of body .....	30	25
Width of head across eyes .....	7.5	7
Expanse of fore wings .....	70	70
Greatest width of fore wing .....	11	11
Length of valve .....	6	.....

The type, allotype and paratype, all collected at the same place and time, are alike in the brilliant orange coloring, resembling somewhat *Okanagana ornata* Van Duzee, except that the wing veins are bright colored to the marginal areas, giving the insect a singularly beautiful appearance. In *cruentifera* and *formosa* the venation about the ulnar and marginal areas is fuscous.

***Okanagana lurida* Davis (Plate 3A, Fig. 5).**

This species was described and figured in this JOURNAL, June-September, 1919, from a male in the collection U. S. National Museum collected at Pullman, Washington (C. V. Piper). In this JOURNAL, March, 1925, page 46, is the record of a second male in the National Museum collection, also collected at Pullman, Washington (C. V. Piper). Lately Mr. Paul W. Oman, in charge of the cicadas in the National Museum, kindly sent to me several specimens for determination, and among them are a male and female labeled: "Pullman, Washington (C. V. Piper)."

As these specimens are no doubt of the original lot, it is advisable to mention that the female of *lurida*, not available in 1919, has the notch in the last ventral segment broad with an indication of an inner notch. The length of the body is 24 mm., and the wings expand 65 mm. The venation is pale as recorded in the original description, with the basal cell of the fore wing clear or nearly so. The pronotum is margined with pale orange, very narrowly so on the anterior margin. The orange at the base of all of the wings is paler than in *Okanagana bella*, in which the basal area of the fore wing is opaque, and the notch in the ventral segment of the female is single. In *Okanagana occidentalis*, from the same general region as *lurida*, the head is hairy and the pronotum is black on the lateral edges.

From specimens in the collection of the U. S. National Museum

it appears that *lurida* is to be found also in British Columbia and Oregon, and that some individuals are darker colored than those of the original series.

### **Okanagana nigrodorsata** Davis.

Most species of *Okanagana* are more easily identified when the wings are spread and their general shape and the colors of the basal membranes are seen. *Okanagana nigrodorsata*, however, has an outstanding distinction even with closed wings, when the orange, basal margin of the hind wings show as conspicuous, oblique bars against the insect's coal black body.

The species was described in this JOURNAL for March, 1923, and additional specimens, 24 in all, mentioned in the JOURNAL for June, 1932, p. 253. All were collected in June or July in the northern half of California. On June 29, 1935, Dr. Raymond H. Beamer and his associates collected 14 specimens of this species at Weed, Siskiyou County, California.

### **Okanagana ferrugomaculata** new species (Plate 3B, Fig. 4).

Type male, Aspen Lake, Klamath County, Oregon, June 18, 1934 (Kenneth McLeod, Jr.). Collection U. S. National Museum.

Resembles *Okanagana bella* in size and color but has a broader head, narrower wings, a longer uncus and the hind margins of the abdominal segments are more completely and conspicuously bordered with orange.

Head more deeply set in the pronotum than in *bella* with the result that the eyes are not prominent; front but slightly produced, median sulcus well defined. Pronotum with anterior angles rather sharp. Last ventral segment slightly truncated at the rounded extremity. Uncus when viewed in profile not as short and deep as in *bella*, but with the lower surface more gradually upturned toward the extremity. In *bella* the valve extends beyond the uncus, whereas in *ferrugomaculata* it is more nearly of the same length; when viewed from above with a shallow notch at the extremity. Fore wings nar-



OKANAGANA FERRUGOMACULATA

row, with dark venation except the front margin to end of radial cell; basal area black with the membranes of both pair of wings brilliant orange-red, as in *bella*.

Head black with the supra-antennal plates and the transverse grooves in front of the central ocellus, and the one immediately behind, orange. The region of the transverse rugae black bordered by orange; rostrum black orange at base. Pronotum nearly black bordered with orange, very narrowly on the anterior margin, with a large irregular rust-colored area each side of the central groove. Mesonotum shining black bordered on the sides posteriorly with orange, and an orange spot at the base of each fore wing. The elevated  $\times$  has the fore limbs touched with orange, in front of which are the usual four orange spots arranged in a semi-circle. Metanotum black edged posteriorly with orange. Tergum shining black with the segments plainly edged posteriorly with orange. Beneath, the legs are orange blackened at the joints and considerably blackened on the inner side of the fore femora. The abdominal segments are black centrally, broadly orange on the posterior margins, also with a black spot on each segment at the sides. Uncus black, valve black orange at the sides along the upper margin.

#### MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body .....	24
Width of head across eyes .....	8
Expanse of fore wings .....	61
Greatest width of fore wing .....	10
Length of valve .....	4

In the writer's collection there are two males that closely resemble the type, one labeled Nevada County, California, June 20, 1913 (F. W. Nunenmacher), and the other from Yosemite, California, June, 1931. In the collection of the U. S. National Museum there is a female from Siskiyou County, California, that probably belongs to this species. The notch in the last ventral segment is broad and single, that is, there is no inner notch.

#### *Okanagana canadensis* Provancher.

On July 13, 1935, Mr. Paul W. Oman collected a male of this species in the low hills southeast of Salt Lake City, Utah, and states that, along with some other cicadas, it was found on sage brush. This is a western record for *canadensis* in the United States, and so far the only one west of the Continental Divide. A single male *canadensis* has been recorded from Strontia

Springs, Douglas County, Colorado. (See JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY, March, 1930, p. 6.)

In Canada, *Okanagana canadensis* has been found in New Brunswick, Quebec, Ontario, Manitoba, and Alberta. *Okanagana rimosa* Say, which like *canadensis* is a species of northern distribution, has been found west of the Continental Divide, so the discovery of the closely allied *canadensis* in Utah is not as remarkable as it might at first appear.

### *Okanagana opacipennis* Davis.

The female type of this beautiful species was collected by Prof. W. S. Wright at Buckman Springs, San Diego County, California, June 23, 1925, and the next year he collected a male on June 26 at the same place. Both specimens were found on manzanita, the bark of which is also reddish in color, and the cicadas are thus inconspicuous when resting on the bush. *Okanagana arctostaphylæ* Van Duzee, and *Okanagana rubrovenosa* Davis, also occur on the manzanita, and are reddish in color. (See JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY, June, 1926, and December, 1927).

On June 6, 1935, Mr. Paul W. Oman collected a male *opacipennis* at Cajon, San Bernardino County, California, about 120 miles northwest of Buckman Springs. This specimen is brownish-red in general color. The head is dark about the eyes; pronotum dark at sides; mesonotum of a brownish color with slightly reddish tint; abdomen greenish brown with the usual triangular black area on dorsum; black spot each side on segments 2-8; uncus dark at sides with paler dorsal stripe; valve pale. Under side of head at eyes dark; rugæ pale; legs pale; abdomen pale. Wings of a pinkish brown color, both pair reddish-orange at base. This individual departs considerably in color from the three other known specimens.

On August 3, 1935, Dr. Raymond H. Beamer collected a male *opacipennis* at Idyllwild, Riverside County, about 70 miles north of Buckman Springs. It is quite like the female type and of the same reddish color. Dr. Beamer writes as follows: "I took this specimen from manzanita on a mountain slope one afternoon. It sang and I walked over to it. It buzzed out to the ground and was captured quite easily, due perhaps to the injured wing.



Recognizing that it was a good thing the whole party spent the next half day there but without success. We heard them but they would not sing long enough for us to penetrate the brush to them. They sang for but a few seconds and then not again for some time."

**Okanagana rubrovenosa** variety **rubida** new variety.

The species was described in the JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY for March, 1915, from a male collected in Mariposa Co., California, June 15, 1914, and the statement is made that the "dorsum is black, but has a dull reddish appearance owing to its covering of rufus hairs." In giving further records of the species (JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY, June-Sept., 1919), a female, collected at Keddie, Plumas Co., California, June 28, 1918, by Frank Morton Jones is described, and it is stated: "body black above covered with short reddish hairs, which give it a rusty appearance. The tergum is black where denuded of hair."

This beautiful insect is found on manzanita bushes, the reddish bark of which the cicada closely matches in color. Specimens are now in the writer's collection from Oregon, California, Arizona and Utah, and it has been found that in some of the broods or colonies, the insects have black bodies, as mentioned in the original description, while in other colonies the insects are almost entirely red in color, including the veins of the wings, except for the vertical darker stripes usually present on the sides of the abdomen.

For this color variety the name *rubida* is here proposed, and as type and allotype a male from Redding, Shasta County, California, June 28, 1935 (R. H. Beamer), and a female from Dunsuir, Siskiyou County, California, July, 1922 (F. R. Cole), have been chosen.

Specimens from Kirby and Grant's Pass, Oregon, have black bodies, while from the ten counties in California they may be either typical *rubrovenosa* or variety *rubida*. Those in the writer's collection from Buckman Springs, San Diego County, Southern California, have black bodies. From Lake County both dark and light-colored individuals have been received. Eight specimens from Utah have black bodies.

Many specimens without data as to broods have been received from Arizona, and they are usually of variety *rubida*, with an occasional nearly black specimen present. Rarely, however, is the head, pronotum and mesonotum black as in typical *rubrovenosa*.

**Okanagana hirsuta** Davis (Plate 3B, Fig. 1).

This large and extremely hairy species, of which the male is unknown, was described in this JOURNAL, March, 1915, pages 13 and 43, from a female in the collection of the American Museum of Natural History collected on Santa Rosa Island off the coast of Southern California. The hairs are particularly long on the under side and when viewed from above they are seen to form a fringe about the body. The legs are also hairy, and on the hind tibiae they are about twice as long as the diameter of the joints. The basal cell of the fore wing is clear.

What appears to be a new species, or at least a race of *hirsuta*, is found on the Island of Santa Catalina, about 80 miles to the southeast of Santa Rosa.

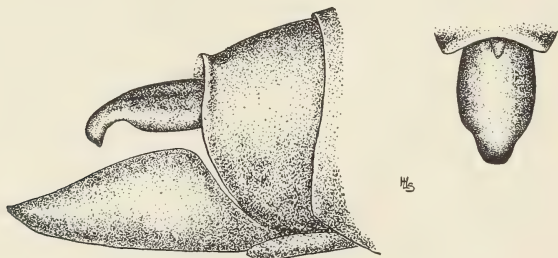
**Okanagana hirsuta catalina** new race (Plate 3B, Figs. 2 & 3).

Type male, Santa Catalina Island, California, June 17. Davis collection.

Allotype, female, Santa Catalina Island, California, June 27 (D. H. Blake Coll.). U. S. National Museum.

Smaller than *hirsuta* with the front of the head not as prominent. Basal membranes of the wings orange, but not as clouded or darkened as in *hirsuta*, which also has blacker venation. Tergum with the segments completely edged with orange posteriorly; in *hirsuta* they are orange on the sides only.

Head nearly as wide as the anterior margin of the pronotum; front and eyes not prominent; median sulcus narrow with parallel sides. Last ventral segment in the type with a shallow but well defined notch at the extremity. In the allotype the ventral notch is broad with an indication of an inner notch. The uncus is hooked at the extremity and shaped as illustrated. It is smaller than in *vanduzeei* and other species of equal size in which the uncus is hooked. Fore wings with the basal cell clear. As in *hirsuta* this is a very hairy insect. Many of the hairs on the hind tibiae are more than twice as long as its diameter.



OKANAGANA HIRSUTA CATALINA

Head black; supra-antennal plates touched with orange, and a transverse orange spot in front of the central ocellus. Pronotum black out to the lateral margins; front margin narrowly edged with orange; hind margin more broadly so. In the allotype there is an irregular paler area each side of the central line. Mesonotum black, hind margin orange; X orange in part, with the four spots in front of the X arranged in a semi-circle. Orange near the base of each fore wing. Metanotum margined posteriorly with orange. Tergum black, the second segment more broadly margined posteriorly with orange than the remaining segments. Uncus black; valve pale tipped with black. Beneath the central sulcus of the head is bright orange; the legs are pale striped with black; the abdominal segments are orange, each one with a black spot at sides; the central portion with the segments black at base, but in some the blackened portion is very narrow.

## MEASUREMENTS IN MILLIMETERS

	Male Type	Female Allotype
Length of body .....	23	22
Width of head across eyes .....	7	7
Expanse of fore wings .....	63	64
Greatest width of fore wing .....	10	10
Length of valve .....	3.5	.....

***Tibicinoides mercedita* plays possum.**

In the original description of *T. mercedita* in this JOURNAL, March, 1915, twenty-two specimens are recorded, all collected in Merced County, California, June 18, 1914.

On June 8, 1935, Mr. Paul W. Oman collected 21 males and 10 females at Lancaster, Los Angeles County, California, and on June 12, 1935, four males and one female at Califa, Madera County, California. Of the Lancaster colony Mr. Oman wrote: "The males were singing in short clumps of grass, and when approached or otherwise disturbed, immediately folded up their legs, released their hold on the grass stem, and dropped to the ground. The females did the same. Specimens could be picked up and handled without their showing any signs of life, and after dropping to the ground it would be several minutes before they again climbed up a grass stem. I do not recall seeing a single specimen in flight."

Mr. Franklin T. Scott kindly sent me 10 males and 5 females of this species taken June 5, 1935, and stated that they were found in the river bottom lands near Visalia, Tulare County, California, on short grass and weeds, and were very numerous.

From the foregoing it would appear that 1935 was a brood year for *Tibicinoides mercedita* in several localities in California.

**Clidophleps beameri** new species (Plate 3B, Fig. 5).

Type male, Cuyama Ranch, California, July 25, 1935. University of Kansas.

Front of head more produced than in any other recorded species of the genus. Median sulcus well defined with the sides nearly parallel and even. Last ventral segment short and the extremity slightly truncate. Uncus as figured. Fore wings broad, pale straw-colored, the veins about the marginal areas but slightly darkened; the central portion bulged outward or upward if the wings are expanded, and the triangular nodus at the outer end of the cubital area prominent, as in *C. distanti* and *C. blaisdelli*. (See this JOURNAL, June, 1926, plate XXIII, and December, 1927, plate XVIII).



CLIDOPHLEPS BEAMERI

General body color pale yellowish or straw color, variegated slightly with fuscous. Front of head with the transverse rugæ slightly darkened near the median sulcus; a curved dark mark surrounding each of the posterior ocelli. Pronotum straw-colored with a spot each side of the central line at the front margin, and each outer groove very slightly darkened. Mesonotum straw-colored with but the two outer obconical marks darkened—the central pair but faintly outlined. Dorsum of the abdomen yellowish with a slightly greenish tinge, each segment with an irregular, central dark spot, also dark spots along the sides to segment IX. The uncus and valve are pale, also the underside of the abdomen. The legs are pale striped and spotted with brown.

#### MEASUREMENTS IN MILLIMETERS

	Male Type
Length of body .....	25
Width of head across eyes .....	7
Expanse of fore wings .....	61
Greatest width of fore wing .....	10
Length of valve .....	4.5



In addition to the type, seven males were collected at the same place and time by the members of the University of Kansas expedition. Cuyama Ranch is along the Cuyama River, a branch of the Santa Maria River, which forms the northern boundary of Santa Barbara County, and the cicadas were collected between fifty and seventy-five miles from the coast. They were in giant sage, and Jack Beamer, an expert cicada collector, was attracted by their peculiar song. "One of them will start and then the whole lot will start up; sing a little while, and then quit just as suddenly as they started." The entire party went cicada hunting, but as the insects favored them with but one or two brief outbursts of song, only a few additional specimens were collected.

#### ***Platypedia occidentalis* Davis.**

This beautiful and highly colored insect was described in this JOURNAL, June, 1920, as a variety of *Platypedia putnami* Uhler, but it is probably a distinct species. The type and allotype came from Trinity County, California, and other specimens from Siskiyou, Mendocino, Sonoma and Marin counties—ten in all.

Since 1920 no other specimens have been seen by the writer until the examination of the four males and five females collected at Weed, Siskiyou County, June 29, 1935, by Dr. Raymond H. Beamer and his associates. The species appears to be confined to the western part of California.

#### ***Platypedia mariposa* Davis.**

On June 28, 1935, Dr. R. H. Beamer collected four males and a female of what appears to be this species at Redding, Shasta County, California. *Mariposa* was described and figured in this JOURNAL, September, 1935, from five specimens from Mariposa County. The Shasta County specimens differ in being generally darker in color, with the membranes at base of all the wings white and less of pale orange surrounding.

#### ***Platypedia scotti* Davis.**

The first specimens of this species seen by the writer were sent by Mr. F. T. Scott, who collected the type and allotype as well as eight paratypes, at Kaweah, Tulare Co., California, May, 1935. The species was figured and described as *P. scotti* in the "JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY" (Vol. XLIII, No. 3, p. 308,

September, 1935). On the cover of the December "JOURNAL, N. Y. ENTOMOLOGICAL SOCIETY" (No. 4), it is stated that No. 3 was published on October 1, 1935.

*Platypedia sierra* Wymore was described in the "Pan-Pacific Entomologist" (Vol. XI, No. 3, p. 143, July, 1935), which number according to "Dates of Publication, 1935," p. 192, of the same journal, was published October 8, 1935.

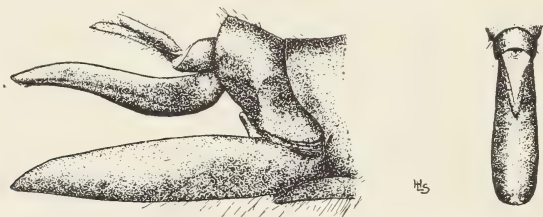
This gives the specific name *scotti* priority.

A comparison with *P. scotti* of the four paratypes of *P. sierra* sent to me October 21, 1935, by Mr. Wymore, show it to be the same species. *Scotti*, by reason of the distinctive shape of the uncus, can be easily separated from other *Platypedia*.

***Platypedia balli* new species (Plate 3B, Fig. 7).**

Type male, Yarnell Heights, Yavapai County, Arizona, June 20, 1935 (Prof. Elmer D. Ball). Collection, American Museum of Natural History.

Resembles the larger *Platypedia keddiensis* and *Platypedia lutea* in color pattern and in having the front wings rather narrow, but the uncus is much flatter than in either. It is separated from the *areolata* and *similis* in having the fore femora black except at tip, instead of chestnut colored, and while at first glance it resembles *P. similis* in size and the pale coloring at base of wings, the uncus is differently shaped, being flattened toward the extremity instead of much arched.



PLATYPEDIA BALLI

Body black above and below, the legs yellow striped with black; fore femora black tipped at the extremity with pale orange. A pale spot above each antenna; pronotum black; front margin narrowly pale with the central groove pale nearly to the collar, which is pale orange. Mesonotum black with a bluish tinge, hind margin pale orange. Metanotum edged with orange. Tergum black with a slightly brassy tinge. Uncus and valve black in type and in the paratypes. Costal margin of the narrow fore wings orange to end of radial area; the venation of the fore wings otherwise darker or fuscous; membranes at base of both pairs of wings pale orange, almost white.

## MEASUREMENTS IN MILLIMETERS

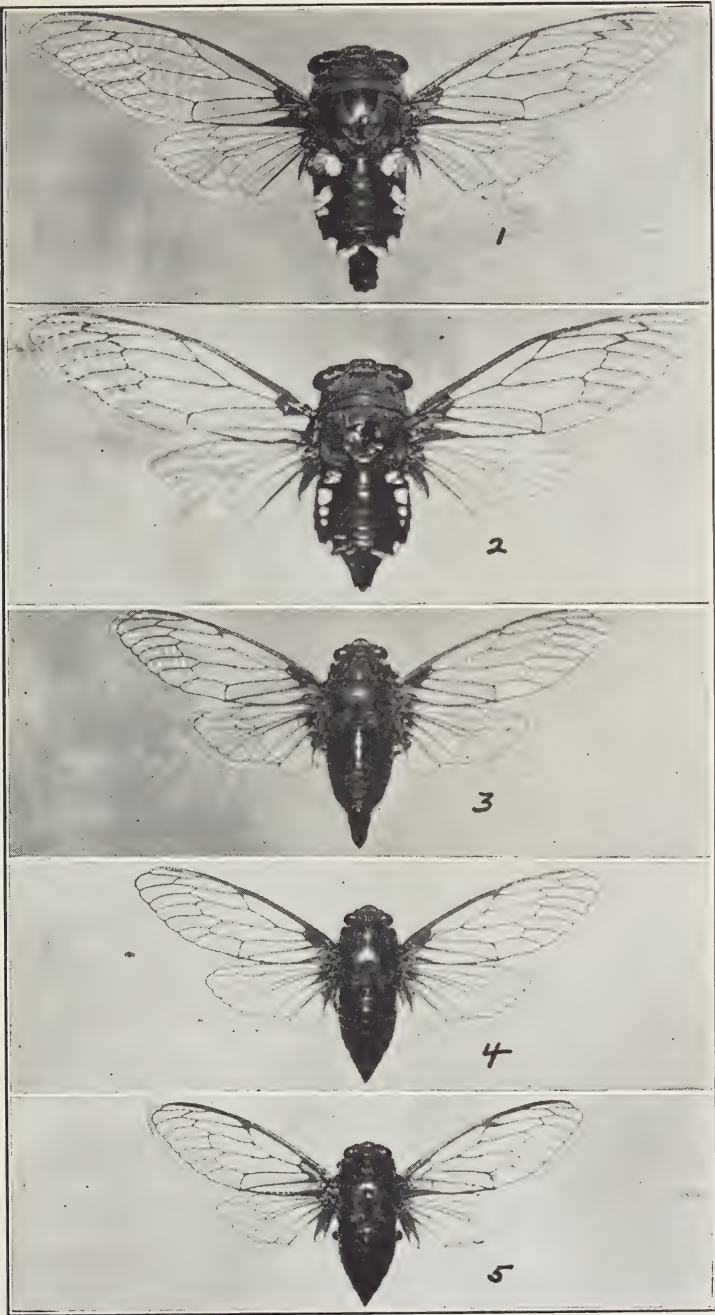
	Male Type
Length of body .....	19
Width of head across eyes .....	6
Expanse of fore wings .....	47
Greatest width of fore wing .....	9
Length of valve .....	4

In addition to the type, four male paratypes have been received from Prof. Elmer D. Ball, all collected at Yarnell Heights, Yavapai County, Arizona, June 20, 1935.

## PLATE 3A

- Figure 1. *Tibicen curvispinosa* new species. Type.  
Figure 2. *Tibicen nigroalbata* new species. Type.  
Figure 3. *Okanagana aurora* new species. Type.  
Figure 4. *Okanagana aurora* new species. Allotype.  
Figure 5. *Okanagana lurida*. Topotype.

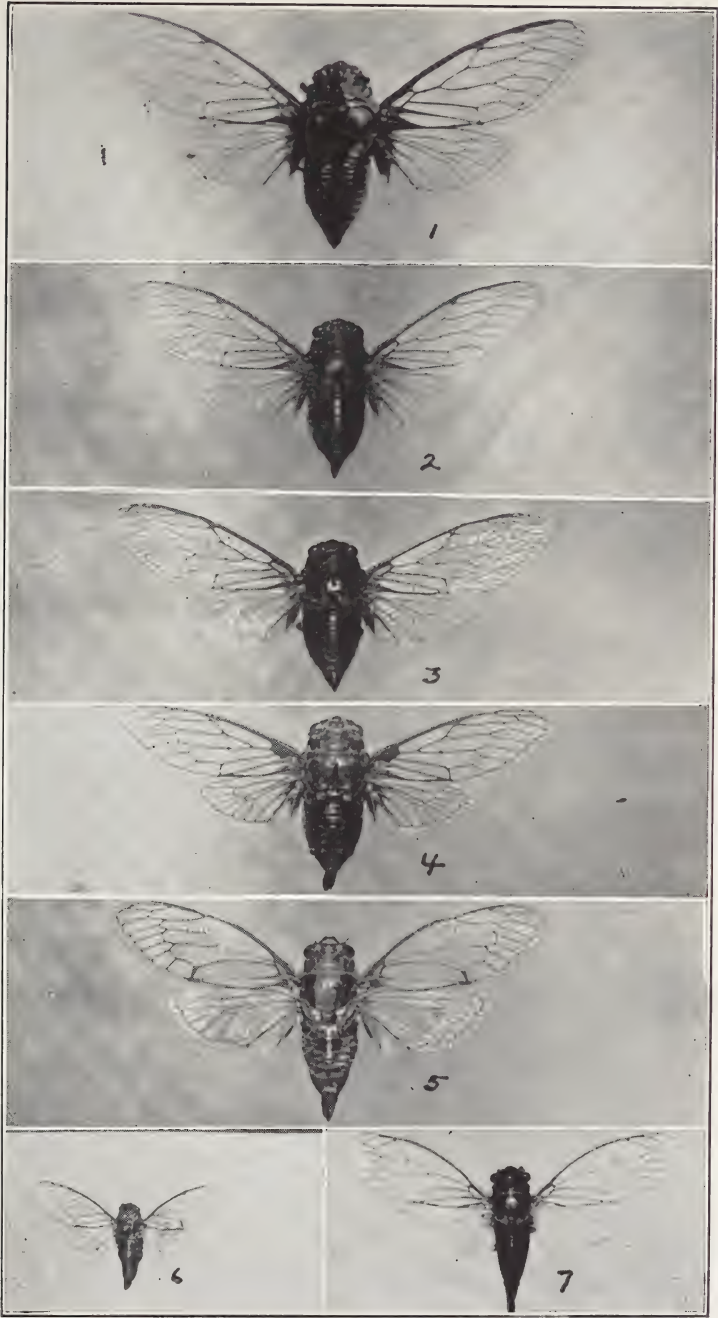




CICADIDÆ

## PLATE 3B

- Figure 1. *Okanagana hirsuta*. Type.  
Figure 2. *Okanagana hirsuta catalina* new race. Type.  
Figure 3. *Okanagana hirsuta catalina* new race. Allotype.  
Figure 4. *Okanagana ferrugomaculata* new species. Type.  
Figure 5. *Clidophleps beameri* new species. Type.  
Figure 6. *Melampsalta texana* new species. Type.  
Figure 7. *Platypedia balli* new species. Type.



CICADIDÆ

*Ancient Artizans. The Wonders of the Insect World.* By Stuart Ward Frost. Boston, The Van Press, Publishers, 1936. 8 vo. 295 p. 152 illus. \$3.50.

It would be interesting to know how individual entomologists came to be interested in entomology. I mean the spark that actually set them off. Did they read something that aroused their interest? Did a professor present the subject so glowingly that, then and there, they decided to embrace the science? Did a friend take them on a collecting trip? Did they acquire their liking, after visiting a museum? Did they enter entomology accidentally through another field? Were they fascinated in their youth by a glamorous display of butterflies on exhibition in the shop window of a German barber, as I was?

All of which speculation was aroused by reading in the preface of Dr. Frost's book that his purpose is to introduce to laymen some of the interesting habits of insects. This is a laudable purpose, no doubt, but I wonder if Dr. Frost didn't actually write his book because it pleased him to do so, because he is intensely interested in his subject and because of his enthusiastic admiration of the things that insects do?

"Insect Artizans" is interesting and easy to read. The insects are humanized and in seventeen chapters the author writes entertainingly of such a diverse crew as foragers, wanderers, hunters, agriculturists, masons, carpenters, spinners, tailors, miners, aviators, paper makers, divers, wax workers, garbage collectors, fishermen, musicians and assassins. At the end of each chapter there are references to the literature for the use of readers who wish to go further.

After enjoying Dr. Frost's book, I thought—what a pleasant way to enter entomology, through accurate accounts of the astonishing things that insects do, and I hope that his work will fall into the hands of readers who are thirsty for more.

H. B. W.



## SYNOPSIS OF THE TABANIDÆ OF NEW YORK, THEIR BIOLOGY AND TAXONOMY

BY BERNARD SEGAL  
UNIVERSITY OF ROCHESTER

(Concluded from page 78)

*Chrysops mitis* O.-S.

(*Chrysops mitis* Osten-Sacken, Memoirs Boston Society Natural History, II: 374, 1876.)

*Female.* Length 9–11 mm., antennæ 2 mm., wings 9–9.5 mm. long, 2.5–3 mm. wide. General body color black. Thorax with two longitudinal grayish stripes on the dorsum. Wings hyaline with a brown picture.

Head:—White and black hair on a ground of yellowish gray pollen covering the face. The callosities are large and lustrous black. Antennal joint 1 cone-shaped, reddish yellow; joint 2 deeply furrowed in the middle, blackish on the outer side, yellowish brown on the inner side; joint 3 black, style thickened at the base. All joints beset with short black hair.

Thorax:—Lustrous black with two longitudinal gray stripes which are interrupted at the middle. Pubescence gray, which on the pleura forms three tufts of long woolly hair, bordered by a row of black hair extending from the roots of the wings to the humeri. Legs generally black; bases of the middle and hind metatarsi reddish yellow.

Wings infuscated at the base, in the costal and subcostal cells and in the proximal halves of the two basal cells. The brown cross-band is undulated in its outer border, which covers the upper halves of the first submarginal and first posterior cells, the entire discal cell, the basal tips of the second and third posterior cells, and basal halves of the fourth and fifth posterior cells. The apex of the first basal cell, and a narrow line along the vein separating the third and fourth posterior cells are brown. The anal cell is faintly infurcated. The apex of the wing, a broad border along the inner margin of the wing, the axillary cell, and the apical halves of the two basal cells are hyaline.

Abdomen:—Lustrous black with grayish delicate hair tending

to form a median row of light pubescence from the scutellum to the apex, and two lateral spots on tergites 1 and 2. Venter black. Sternum 1 bare, all the others clothed with delicate gray hair uniformly distributed.

*Male.* Similar to female. Ground color a dull black. The infuscation fills the greater part of the two basal cells and the cross-band covers the fourth and fifth posterior cell completely.

Distribution:—New York to Washington; Ontario to Virginia.

Synonyms:—*provocans* Wlk., 1850.

*Chrysops niger* Macq.

(*Chrysops niger* Macquart, Dipt. Exot. 1: 161, 1838.)

*Female.* Length 7–9 mm., antennæ 1.5–2 mm., wings 6.5–7.5 mm. long, 2.5–3.5 mm. wide. General color of the body lustrous black. Thorax with two greenish longitudinal stripes. Apex of wing, fifth posterior cell and the second basal cell hyaline.

Head:—Face and front covered with grayish yellow pollen. Facial and cheek callosities shining black, separated from the margin of the eye by a fine line of pollen. Frontal callosity broad, lustrous black. Ocellar area rectangular, with three dark red ocelli on a black background. Antennæ slender, joint 1 reddish yellow, beset with short, thick, black bristles; joint 2 about two-thirds as long as the first, furrowed, and likewise beset with thick, short bristles; basal portion of joint 3 greatly notched, style distinctly annulated, of a dull black color.

Thorax:—Shining black with two longitudinal bands of greenish pubescence. Pleura with olivaceous short hair. Light delicate hair scattered over the entire thorax, but much thicker on the sides than on the dorsum.

Legs black; proximal ends of the front tibiae and all the tarsi light brown.

Wings infuscated on the entire costal margin and first basal cell except at the apical end. The dark cross-band becomes lighter towards the inner margin. The cross-band covers the proximal half of the marginal and the submarginal cells, the first posterior cell, the discal cell, the proximal halves of the second and third posterior cells, and the entire fourth posterior cell. The apex of the wing, the second basal cell, a spot on the apical

end of the first basal and discal cells, the axillary cell and a narrow line on the inner margin of the wing are hyaline.

Abdomen:—Wholly lustrous black bordered by golden yellow delicate hair on the posterior margin of each segment. Venter lustrous black likewise with golden yellow hair, shorter than on the dorsum. No light markings anywhere.

*Male* similar to female.

Distribution: New York to Minnesota; Ontario to Arkansas and Kansas.

Synonym:—*carbonarius* Walker, 1848.

*Chrysops nigribimbo* Whitn.

(*Chrysops nigribimbo* Whitney, Canadian Ent., XI: 36, 1879.)

*Female*. Length 6–7 mm., antennæ 1.5–2 mm., wings 5.5–6 mm. long, 2–2.5 wide. General body color shining black with greenish tone on the dorsum of the thorax. Two longitudinal stripes on the anterior part of the thorax of a light color. No other light pattern anywhere. A very pale dark picture on the hyaline wings.

Head:—Face covered with creamy pollen. The callosities are of a glossy black with a reddish tinge in the central points. Antennæ slender, greatly diverging and curved. Joint 1 light brown, with delicate black hair; joint 2 brown, deeply furrowed, likewise beset with black hair; joint 3 black, lighter on the sinuated basal portion. Style slender, distinctly annulated and curved on the tips. Frontal callosity nearly rectangular, separated from the eyes by a narrow line of grayish green pollen. Ocellar area black with three reddish ocelli. Posterior of head dark with short yellow hair.

Thorax:—The two light longitudinal stripes are vaguely outlined on the anterior of the black thorax, but do not reach the posterior end. Pubescence on the sides of the thorax light yellow. Legs light brown, of a darker tone on the front tibia, the base of middle and hind femora and tarsi.

Wings infuscated at the base, on the first basal and marginal cells. The cross-band is indicated over the proximal half of the first submarginal, the entire discal cells and vanishes gradually

at the middle of the fourth posterior cell. In some specimens the cross-band is hardly visible.

*Male* unknown.

Distribution:—New York, Massachusetts, Connecticut, New Hampshire to North Carolina.

Synonym:—*nigrilimbo* Kertész, 1900.

*Chrysops sordidus* O.-S.

(*Chrysops sordidus* Osten-Sacken. Memoirs Boston Society Natural History, II: 375, 1876.)

*Female*. Length 10.5–11 mm., antennæ 2–2.3 mm., wings, 9.5–10 mm. long, 3–3.5 mm. wide. General body color black, thorax with two broad median stripes of a bluish-green tone. Abdomen with light median triangles, lateral spots, and posterior margins on the tergites. Wings grayish hyaline with a light brown picture.

Head: Face covered with white pollen. Facial and cheek callosities lustrous black. Antennal joint 1 about three times as long as wide, yellowish brown; joint 2 dark brown with yellowish blotches on the inner side, deeply furrowed; both joints beset with strong black bristles. Joint 3 longer than 1 and 2 together, style rather short and thick, distinctly annulated. Front callosity wide and lustrous black. Ocellar dark area vaguely outlined, grayish yellow hair around and between the three shining brown ocelli. Posterior of head black with short gray hair.

Thorax:—Two wide bluish-green stripes which do not reach beyond the middle of the dorsum, are distinct on the dull black background. A very faint bluish black, narrow median line separates the wider stripes. The whole dorsum clothed with yellowish hair, growing longer toward the scutellum. On the pleura they form three dense tufts of long hair; one at the junction of head to the thorax, one between the front and middle coxæ, and one around the middle coxæ, with a row of black, long hair extending from the roots of the wing to the humeri. Legs dull black with lighter spots on the tips of the middle and hind tibiæ and metatarsi. Pubescence of legs short, black, with longer yellowish hair on the femora.

Wings infuscated on the costal and subcostal cells and at the



base. First basal infurcated on the proximal two-thirds and the very apex; second basal less densely infurcated, and over a smaller area than the first basal cell. The light brown cross-band is vague in outline and loses its intensity as it approaches the inner margin of the wing. The outer border covers most of the marginal cell, the proximal halves of the first submarginal and first posterior cells, the entire discal cell, the base of the second posterior cell and obliquely extends over the basal half of the third posterior cell. The fourth and fifth posterior cells are lightly infuscated by the faint outer border of the cross-band, gradually fading toward the margin of the wing. There is also a narrow line of brown along the vein separating the anal and the fifth posterior cells. Scattered dots of brown along the costa mark the continuation of the infurcation of the marginal cell into the apical region of the wing. The hyaline areas are grayish and lusterless.

Abdomen:—Glossy black background with a black pubescence: tergite 1 with a yellow spot on either side; 2 with a light posterior border which expands anteriorly to form a median triangle and lateral spots; 3 to 6 with light posterior borders, tending to form median spots of value outline. Venter yellowish brown with light posterior border, clothed with gray silky hair.

*Male* unknown.

Distribution:—New Brunswick to New York.

#### Group IV. *Virgulatus*

The group is characterized by the club-shaped thickening of the first or first and second antennal joints. The only Eastern representative of this group, *brunneus* Hine, is easily recognized by the peculiar cinnamon brown coloration of the abdomen.

#### *Chrysops brunneus* Hine

(*Chrysops brunneus*, Hine, Tabanidæ of Ohio, Ohio State Academy of Science. Special Paper no. 5, 1903.)

Length 8.5 mm., antennæ 2.5–3.5 mm., wings: 8–10 mm. long, 3–4 mm. wide.

Female. General color of abdomen cinnamon brown. Thorax dark brown with grayish longitudinal stripes. Wings blend with

the general tone of the body, the brown picture being vaguely outlined on a smoky background interrupted by sub-hyaline spots.

Head:—Face covered with gray pollen. All callosities of a shining amber color. Ocellar area dark brown, bearing three black ocelli. Front covered with reddish pollen and dotted by short hair. Antennal joints 1–2 dark reddish-brown, thickened. Joint 3 reddish-brown at base, the rest and the terminal style black.

Thorax:—The dorsum is lustrous brown with two indistinct grayish longitudinal stripes separated by a narrow median brown line. Sides and pleura light brown covered with yellow hair. Scutellum reddish brown. Legs uniformly brownish yellow.

Wings brown on the anterior margin and over  $\frac{2}{3}$  of the first and  $\frac{1}{2}$  of the second basal cell. The cross-band touches upon the apex of the basal cells and fills the entire discal cell. The posterior border of the cross-band extends over the proximal half of the first submarginal and first posterior marginal cell, covers the proximal  $\frac{1}{4}$  of the second and third posterior marginal cells, and fills completely the fourth posterior marginal cell. A slight band of infuscation borders the vein separating the fifth posterior marginal cell and the anal cell. The apical spot covers the entire apical angle of the wing and is separated from the cross-band by a narrow subhyaline crescent.

Abdomen:—The cinnamon-brown coloration is marked by light triangular spots on the posterior margins of tergites 2–4, and by irregular, oblique lateral streaks on tergites 3–7. Venter darkens gradually toward the posterior sternites, and is marked by light median and lateral spots. Pubescence dense silky yellow.

*Male* similar to female. The infuscation of the cross-band invades most of the fifth posterior marginal cell.

Distribution: Ontario to Georgia; New York to Arkansas.

#### Group V. *Callidus*

I. Apical spot of wing confined to a narrow marginal band, not invading the first submarginal cell.

A. Cross-band of wing filling only part of the discal cell, leaving at least the proximal  $\frac{1}{3}$  hyaline.

B. Tergites 1 and 2 of abdomen yellow with a median black spot on 1, and a black horse-shoe figure on 2.

*delicatulus* O.-S.

- BB. Abdomen dark-brown with a narrow, continuous yellow mid-dorsal stripe ..... *wiedemanni* Kroker
- AA. Cross-band of wing filling the entire discal cell, or only a small area at the very base of the cell is light.
- B. Abdomen olivaceous with light, median triangles and lateral spots on tergites 1 and 2 ..... *brimley* Hine
- BB. Abdomen yellow with a black pattern.
- C. Tergite 2 with a black median horse-shoe figure and two small triangular spots on either side. Fourth posterior marginal cell not infuscated on its distal  $\frac{1}{2}$ ; cross-band not reaching the posterior margin of the wing. .... *moerens* Wlk.
- CC. Tergite 2 of abdomen without black spots on either side of the median horse-shoe figure. Fourth posterior marginal cell completely infuscated ..... *callidus* O.-S.
- II. Apical spot of wing invading the first submarginal cell.
- A. Apical spot linear in outline; only slightly broader than the brown costal margin above the stigma.
- B. Abdomen mostly dark. Tergite 2 with a yellow median triangle and lateral spots. Fourth posterior cell of wing covered by the brown of the cross-band over the proximal  $\frac{3}{4}$  only; cross-band not reaching the posterior margin of wing ..... *sackeni* Hine
- BB. Abdomen mostly yellow or pale brown.
- C. Abdominal tergite 1 with a brown circular spot, 2 with an inverted heart-shaped figure ..... *pudicus* O.-S.
- CC. Abdominal tergite 1 without dark spot, 2 with faint brown horse-shoe figure ..... *flavidus* Wied.
- AA. Apical spot of wing large, broader than the brown costal margin.
- B. Apical spot confluent with the cross-band; hyaline triangle not extending across the entire first submarginal cell.
- C. Abdominal tergite 2 with a black horse-shoe shaped figure enclosing a yellow triangle on the posterior border ..... *dimmocki* Hine
- CC. Abdominal tergites 2-4 each with four black spots. .... *montanus* O.-S.
- BB. Cross-band of wing separated from the apical spot; apex of hyaline triangle extending across the second longitudinal vein.
- C. Abdomen mostly yellow with black markings; tergite two with two narrow vertical bars, converging anteriorly.
- D. Abdominal tergite 1 with a brown spot just beneath the scutellum. Scutellum brown. .... *geminatus* Wied.
- DD. Abdominal tergite 1 with two circular brown spots. Scutellum greenish ..... *lateralis* Wied.

*Chrysops brimleyi* Hine

(*Chrysops brimleyi* Hine. Canadian Entomologist, XXXVI: 55, 1904.)

Length 7-7.5 mm., antennæ 2-2.3 mm., wings 6.5-7 mm. long, 2.3-2.5 mm. wide.

*Female.* General body color olive with a gray pubescence. Thorax striped, abdomen with light patterns. Wings hyaline with brown picture.

Head:—Face covered with creamy pollen. Facial callosities shining yellow. Cheeks black. Frontal callosity black, rounded. Ocellar area black with three yellowish ocelli. Antennal joints 1 and 2 light brown with short black bristles, longer on the furrowed second joint. Joint 3 with a light base, the rest and the annulated terminal style black.

Thorax:—A fine median brown line separates two gray longitudinal stripes which do not quite reach the middle of the dark olive dorsum. Pleura greenish with long gray hair. Legs black, basal parts of the tibiæ, and middle and hind tarsi light brown, all parts with short black hair.

Wings brown at the base, along the costal margin, and on the apical angle. The cross-band touches on the apex of the first basal cell, fills completely the discal cell except the very basal tip, and with its posterior border extends from the stigma to fourth posterior marginal cell. The hyaline triangle separates the narrow apical spot from the cross-band. The entire fifth posterior marginal cell, the anal cell, the axillary cell and most of the basal cells hyaline.

Abdomen:—Tergite 1 lustrous olive with light posterior margins expanding into a median triangle and lateral spots. Tergite 2 with a light posterior margin and two circular spots in the center. The other tergites olive brown with light posterior margins. Hair delicate black on the dark areas, white on the light parts. Venter brown with white hair.

*Male* unknown.

Distribution.—New York to North Carolina.



*Chrysops callidus* O.-S.

(*Chrysops callidus* Osten-Sacken, Memoirs Boston Society Natural History II: 379, 1876.)

Length 7-9 mm., antennæ 1.5-2.5 mm., wings 7.5-8.5 mm. long, 2.5-3 mm. wide.

*Female.* Bright yellow with outstanding black patterns on the abdomen. Brown longitudinal stripes on the greenish thorax. Wings hyaline with brown picture distinctly outlined.

Head:—Face covered with yellow pollen. Facial callosities and cheeks glossy yellow. Frontal callosity black, connected with the black ocellar area by a narrow black line. Space between and around the three brown ocelli covered with gray pollen and long yellow hair. Antennal joint 1-2 light yellow on the inner sides, dark on the outer sides, with strong black bristles, joint 3 yellow on the basal portion, the rest and annulated terminal style black.

Thorax:—The narrow median brown line separates two greenish-gray line longitudinal stripes. These are bordered by brown longitudinal stripes, followed by light green lateral stripes. Pleura green clothed with long yellow hair. Legs black, front femora, middle and hind tibia and the basal parts of all metatarsi yellow. Hair on the dark parts black, on the light parts reddish-yellow.

Wings brown at the base and on the very tips of the two basal cells. The costal margin to the apical angle presents a broad brown border. Cross-band touches with its anterior border the apices of the two basal cells and fills the entire discal cell. The posterior border extends over the proximal halves of the first submarginal cell and first posterior marginal cell, covers the bases of the second and third posterior marginal cells, and nearly fills the entire fourth posterior marginal cell. Base of fifth posterior marginal cell and along the vein separating it from the anal cell brown. The hyaline triangle reaches from the second longitudinal vein to the inner margin of the wing. The anal, the axillary, and the middle part of the two basal cells hyaline.

Abdomen:—Tergites 1-2 mostly yellow, with a black quadrangular spot on the first and a horse-shoe figure on the second. Neither of these figures reaches the posterior margin of the seg-

ment. The light posterior margin of the second tergite expands into a yellow median triangle. Tergites 3-4 with the yellow darker in tone, and the black diffused over a larger area. The median black figures encompass yellow median triangles which are expansions of the light posterior borders. The black is more prominent in the remaining tergites occupying the anterior halves of the segments. Venter yellow on sternites 1-2, with narrow vertical black lines on either side of the second sternite. Sternites 3-4 yellow with black median spots and lateral vertical lines. The other sternites black on the anterior halves, and yellow on the posterior borders. Hair on the dark areas black, on the yellow sides and triangles of the dorsum and the entire venter light yellow.

*Male.* Similar to female. Basal cells of wings more infurcated on the proximal end. The black quadrangle on the abdomen occupying most of the first tergite. The black also dominating on the last 3 segments.

Distribution:—Ontario to Florida; New York to Kansas.

*Chrysops delicatulus* O.-S.

(*Chrysops delicatulus* Osten-Sacken, Memoirs Boston Society Natural History, II: 380, 1876.)

Length 6.5-7 mm., antennæ 1.5-2 mm., wings 6.3-6.8 mm., long 2.2-2.5 mm. wide.

*Female.* Thorax with longitudinal gray and brown stripes. Abdomen chocolate brown with yellow markings. Wings glossy hyaline with a brown picture.

Head:—Face covered with gray pollen and white silky hair. Facial callosities and cheeks amber colored. Frontal callosity shining black. Ocellar area black with three reddish brown ocelli. Vertex with yellowish hair. Antennal joint 1 yellow with a dark tip, 2 bluish-black, furrowed, clothed with thick black bristles. Joint 3 and annulated terminal style black.

Thorax:—The narrow median reddish-brown line is bordered on either side by a bluish-gray longitudinal stripe. Next follow broad chocolate-brown bands which converge toward the scutellum. The sides are bluish-gray. The dorsum is clothed with gray hair which is longer and thicker on the sides. Legs dark

brown, bases of all tibiae and the middle and hind metatarsi yellow.

Wings brown at the base and tips of the two basal cells, and along the costal margin. Cross-band touches with its anterior border on the apex of the first basal cell, the posterior border extends almost vertically from the stigma to the inner margin of the wing. It covers the proximal halves of the first submarginal, first posterior marginal, the bases of the second and third posterior marginal, about three-fourths of the discal, and the entire fourth posterior marginal cells. A narrow border along the vein separating the fifth posterior marginal and the anal cells in light brown. The apex of the hyaline triangle interrupts the brown costal margin at the stigma. Most of the basal cells, the basal one-quarter of the discal cell, the anal, axillary, and the fifth posterior marginal cells are hyaline.

Abdomen:—Tergite 1 with a chocolate brown, narrow anterior margin and a quadrilateral black bar which broadens toward the posterior margin, but does not quite reach it. The posterior margin and the sides are yellow. Tergite 2 with a brown horse-shoe figure enclosing a yellow triangle. The posterior margin and the sides are yellow. Tergites 3-4 brown with light posterior margins and small yellow median triangles and sides. The other tergites black with broad light posterior margins. Venter yellow on sternites 1-2, sternite 3 with a brown base and middle spot. The other sternites brown with broad gray posterior margins. Pubescence everywhere delicate gray.

*Male* unknown.

Distribution:—Maine, Massachusetts, New York, New Jersey.

*Chrysops dimmocki*, Hine

(*Chrysops dimmocki*, Hine, Ohio Naturalist, VI: 393, 1905.)

Length 8-8.5 mm., antennæ 2-2.3 mm., wings 7.5-8 mm. long, 2.3-2.5 mm. wide.

Female. Thorax with alternating green and brown stripes. Abdomen with a middorsal row of yellow triangular spots enclosed by semicircular black figures. Wings hyaline with a brown picture.

Head:—Face covered with golden yellow pollen and pale yellow hair. Facial callosities and cheeks reddish-yellow. Frontal

callosity amber-colored. Ocellar area black, bearing three brown ocelli. Antennal joints 1-2 yellow beset with short black bristles. Base of joint 3 reddish-yellow, the rest and the terminal style black. Front and vertex with gray pollen and short whitish hair.

Thorax:—The middorsal brown narrow line separates the two wide longitudinal green stripes. These are followed by lustrous brown stripes of the same width. Sides green with a bluish tinge on the anterior part. Pleura yellow, with a brown stripe extending from base of thorax to base of wing. Pubescence pale yellow. Legs reddish-yellow. Tips of all tibiae, the front tarsi, and the tips of the middle and hind tarsi dark. Scutellum green with yellow apex.

Wings brown on the anterior margin and at the base, including about one-third of the first and basal cells. The apical spot covers about three-fourths of the cell enclosed by the branches of the third longitudinal vein. The cross-band touches upon the apex of the first basal cell and leaves a hyaline spot in the basal part of the discal cell. The posterior border of the cross-band extends irregularly toward the fourth posterior marginal cell which it fills completely. Second basal cell, except for a brown band at base, fifth posterior, anal and axillary cells hyaline. Hyaline triangle reaches with its vertex across the third longitudinal vein into the middle of the first sub-marginal cell.

Abdomen:—Tergite 1 yellow with a quadrilateral brown figure, just beneath the scutellum, reaching down three-fourths of the segment. Tergite 2 yellow, with a black horseshoe-shaped figure enclosing a yellow triangle. The black figure reaches neither of the borders of the tergite. Anterior three-fourths of tergites 3-5 black, with yellow sides and posterior borders which expand into triangular figures cutting into the black. The yellow on the sides also expands anteriorly and is continuous with the yellow of the preceding segments. Tergites 6-7 black with light posterior borders. Venter reddish-yellow with brown spots on sternites 4-5. Sternites 6-7 brown with light posterior borders. Pubescence yellow in the light areas, otherwise black.

Male easily associated with the female of this species by the pattern of the abdomen. The second basal cell is infuscated



over the proximal half. The brown of the cross-band invades the fifth posterior marginal cell.

Distribution:—Massachusetts to Georgia: Long Island to Ohio.

*Chrysops flavidus* Wied.

(*Chrysops flavidus*, Wiedemann—*Diptera exotica* I: 105, 1821.)

Length 8.5–9 mm., antennæ 2–2.3 mm., wings 8–8.5 mm. long, 2.5–3 mm. wide.

*Female.* Abdomen yellow with a faint brown pattern. Thorax with alternating brown and gray longitudinal stripes. Wings grayish hyaline with a pale brown picture.

Head:—Face covered with yellow pollen and white long hair. Facial callosities honey yellow. Frontal callosity semicircular, yellow. Pollen above the callosity to the posterior of the head white. Ocellar area brownish with three large dark brown ocelli. Front and vertex with long yellow hair. Antennal joints 1 and 2 yellow with strong black bristles; joint 3 reddish at the base, the rest of the joint and the annulated terminal style black.

Thorax:—A narrow median brown line, running the entire length of the dorsum, separates two broad grayish stripes. The latter are bordered by yellow lateral stripes. Pleura grayish-yellow with long gray hair. Legs reddish-yellow, the tips of the tibiæ and all the tarsi dark.

Wings infuscated at the base, over about one-half of the first basal, and the very tip of the second basal cell. The entire costal margin to the apical angle presents a broad brown border. The cross-band touches upon the apex of the first basal cell with its anterior border, fills the entire discal cell, and covers the apex of the anal cell. The posterior border extends over the proximal halves of the first submarginal and first posterior marginal cells, covers the base of the second posterior and obliquely about one-half of the third posterior, and completely the fourth posterior marginal cells. There is a narrow brown band along the vein separating the fifth posterior marginal cell and the anal cell. The hyaline triangle extends from the middle of the first submarginal cell to the inner margin of the wing.

Abdomen:—Tergite 1 pale yellow; 2 similar in color on the sides, with a faint outline of a brown horse-shoe pattern in the

middle. Tergite 3 darker in tone with two circular brown spots in the center. The other tergites with irregular dark markings on the anterior halves and grayish-yellow posterior margins. Venter yellow with dark markings on sternites 4-7.

*Male.* Similar to female. Stripes on thorax less distinct, basal cells of wings more infurcated than in the female.

Distribution:—Ontario to Florida; Long Island to Kansas.

Synonyms:—*canifrons*, Walker, 1848.

*pallidus*, Bellardi, 1859.

*Chrysops geminatus* Wied.

(*Chrysops geminatus*, Wiedemann, Aussereuropäische Insecten, I: 205, 1828.)

Length 6-7.5 mm., antennæ 1.8-2 mm., wings 6-7 mm. long, 2-2.5 mm. wide.

*Female.* Thorax with alternating dorsal greenish and brown stripes of equal width. Abdomen yellow dominating on the first two tergites, the rest black with a narrow median yellow longitudinal stripe. Wings hyaline with brown picture in which the apical spot is separated from the cross-band.

Head:—Face covered with yellow pollen and silky whitish hair. Facial callosities yellowish-brown, with darker outer borders. Frontal callosity dull black. Ocellar area black with three brown ocelli. Front and vertex covered with grayish-green pollen and gray hair. Antennal joints 1-2 reddish-yellow beset with short black bristles. Joint three reddish-yellow on basal part, the rest and the annulated terminal style brown.

Thorax:—The brown median line separates two greenish stripes which in turn are bordered by brown stripes distinctly reaching the scutellum. Sides yellow, separated from the bright yelloww pleura by a brown stripe from base of thorax to base of wing. Pubescence short, yellow. Legs yellow with dark terminal parts of the front and hind tibia, and tips of all tarsi. Scutellum brown. Wings brown on the tip of the first basal cell and along the costal margin. Apical spots covers the second submarginal cell except at its very base. Cross-band touches upon the tip of the first basal cell and fills the discal cell, but leaves a light triangular spot at basal tip. The posterior border of the cross-

band runs convexly from the stigma to the posterior margin of the wing leaving a narrow light band on the border of the fourth posterior marginal cell. The hyaline triangle reaches the anterior margin, thus separating the apical spot from the cross-band. The vein between the fifth posterior and the anal cell is infuscated on either side. The fifth posterior, the anal, axillary and the second basal cells, are hyaline.

Abdomen:—Tergite 1 yellow with a brown quadrangular spot just beneath the scutellum. Tergite 2 yellow with two oblique brown lines, often contiguous on the anterior ends giving the appearance of a horseshoe figure. Tergites 3–4 each with two square brown blocks, separated on the middorsal line by a narrow yellow stripe and bordered by yellow posterior margins and lateral lines. Tergites 5–7 brown with light posterior margins. Venter yellow with median brown square spots on sternites 4–5. The terminal sternites brown with light posterior borders. Pubescence short, yellow.

*Male.* Similar to female. Infuscation at the base of the wing invades the basal parts of both basal cells. More hairy than the female on the thorax.

Distribution:—Ontario to Georgia; Long Island to Ohio.

Synonym:—*Chrysops fallax*, Osten-Sacken, 1876.

*Chrysops lateralis* Wied.

(*Chrysops lateralis* Wiedemann, Aussereuropäische Zweiflügelige Insecten, I: 209, 1828.)

Length 8–9 mm., antennæ, 1.8–2 mm., wings 7.5–8 mm., long, 2–2.5 mm. wide.

*Female.* Thorax greenish with brown longitudinal stripes. Abdomen reddish-yellow with a black pattern. Wings clear hyaline with a pale brown picture.

Head:—Face covered with golden yellow pollen, and yellow silky hair. Facial callosities yellow. Cheeks lustrous black. Frontal callosity black, rounded above. Ocellar area black, obscured by the gray pollen, bearing three black ocelli. Antennal joint 1 yellow, joint 2 dark, furrowed, beset with black bristles. Joint 3 and the curved terminal style black.

Thorax:—The narrow, brown, median line is bordered on either

side by a wide green stripe, which in turn are followed by brown stripes, narrow at the anterior and widening toward the scutellum. Sides greenish, separated from the yellow pleura by a narrow brown stripe. Dorsum clothed with fine yellow hair, pleura with long reddish-yellow hair. Scutellum green. Legs yellow, basal half of the hind femora and all tarsi black.

Wings brown at base on tip of first basal cell, and costal margin which broadens into the apical spot beyond the stigma. Cross-band touches upon the apex of first cell with its anterior border, fills the discal cell and is limited by the veins of the fourth posterior marginal cell. The posterior border extends roundly from the stigma to the inner margin of the wing, covering the proximal halves of the marginal, first submarginal, about one-fourth of second, one-third of third, and the entire fourth posterior marginal cell, except for a narrow, clear margin. The apical triangle, the fifth posterior marginal cell, the anal, axillary, and second basal cell, hyaline.

Abdomen:—Tergite 1 reddish-yellow with two small circular spots. Tergite 2 yellow with two vertical black bars. Tergites 3–4 each with four vertical black bars, which in tergite 5 are fused to form two black masses separated in the middle by a wedge-like expansion of the yellow posterior margin. On tergites 6–7 the black occupies most of the anterior parts of the segment. Venter yellow, with median black spots on sternites 3–4, and black anterior margins on sternites 5–7. Pubescence golden yellow.

*Male.* Similar to female. Brown picture of wing darker, and black pattern on abdomen more pronounced than in the female.

Distribution: Quebec to Pennsylvania, New York to Kansas.

Synonyms:—*hilaris*, Osten-Sacken, 1876.

*Chrysops moerens* Wlk.

(*Chrysops moerens* Walker, List of Diptera British Museum I: 201, 1848.)

Length 9–9.5 mm., antennæ 2.2–2.5 mm., wings 8.5–9 mm. long, 2.5–3 mm. wide.

*Female.* Thorax bluish with longitudinal black stripes. Abdomen brown with yellowish patterns. Wings clearly hyaline with an outstanding brown picture.



**Head:**—Face covered with gray pollen. Facial callosities and cheeks reddish-brown. Frontal callosity semicircular, black. Ocellar area pollinose, ocelli reddish. Oral margin with silky white long hair. Vertex with black hair. Antennal joint 1 yellow at the base and on the inner side, brown on the outer side; joint 2 similarly colored, furrowed; both joints beset with short black bristles, joint 3 reddish at the base, the rest, and the annulated style black.

**Thorax:**—The dorsum presents a pattern of alternating black and lighter longitudinal stripes. On the mid-dorsum is a narrow black line, distinct in its entire length from the anterior margin of the thorax to the scutellum. On either side of this line are wide bluish-white bands which grow indistinct as they approach the scutellum. Next to these are black stripes which merge with the black posterior border of the thorax. Humen with pale yellow patches. Pleura reddish brown with tufts of long white hair bordered by a row of strong black hair from the base of the thorax to the base of the wing. Scutellum bluish with long yellow hair. Legs black, basal half of the front tibia, and the middle and hind metatarsi reddish-yellow. Pubescence short, black.

Wings infuscated at the base and on the bases of the two basal cells. The costal cell is slightly brown along the longitudinal vein. The cross-band covers the proximal halves of the marginal, first submarginal and first posterior cells; touches upon the apices of the two basal cells, fills completely the discal cell, and extends roundly over the basal parts of the second, third and fourth posterior cells. The fifth is infurcated only along the veins. The apex of the wing, anal and axillary cells, and the middle portions of the basal cells, clearly hyaline.

**Abdomen:**—Tergite 1 brown with a yellow posterior border which expands to form two lateral blocks. Tergite 2 with a yellow median triangle and two lateral spots just beneath those of the first tergite and sometimes fusing with them. The yellow lateral spots have the appearance of horse-shoes, due to small, lateral, black, triangular spots on the posterior border of the tergite. Tergites 3-4 with a wide posterior light border and a median triangular spot. Tergites 5-6 dark brown with narrow posterior light borders which in the middle tend to enlarge into

triangular spots. The abdomen is clothed with black hair on the brown parts, and longer white hair on the light areas. Venter dark brown with yellow lateral spots on sternites 1-3. All sternites with light posterior borders and clothed with silky white hair.

*Male.* Smaller and darker than the female. Abdomen dull black with the characteristic yellow posterior borders, lateral spots and median triangles.

Distribution: New York to Kansas; Ontario to Pennsylvania.

Synonyms: *aestuans* van der Wulp, 1867.

*Chrysops sackeni* Hine

(*Chrysops sackeni*, Hine, Ohio State Academy of Science, special paper No. 5: 42, 1903.)

Length 8-10 mm., antennæ 2 mm., wings 7.5-9 mm. long, 2.5-3 mm. wide.

*Female.* General color of abdomen reddish-yellow with a brown pattern. Thorax greenish with brown longitudinal stripes. Wings glossy hyaline with brown picture distinctly outlined.

Head:—Face covered with pale yellow pollen and whitish-yellow hair. Facial callosity and cheeks yellow. Frontal callosity yellow on the convex disk yellow, dark brown on the margin. Front above the callosity covered with gray pollen. Ocellar area black, bearing three black ocelli. Antennal joints 1-2 yellow, beset with strong black bristles, joint 3 yellow at base, the rest and the annulated terminal style black.

Thorax:—The median, narrow, brown line separates two wide greenish longitudinal stripes. These are bordered by brown stripes which distinctly reach the scutellum. Sides yellow, separated from the pale yellow pleura by a narrow brown line. Dorsum clothed with yellow hair mixed with delicate short black hair. Legs yellow, with brown bases of front and middle, and most of the hind femora, and all tarsi.

Wings infuscated at base, and the basal parts of the two basal cells, and on the costal margin. The cross-band touches on the apex of the first basal, fills completely the discal cell, extends with its posterior border over the proximal halves of the first sub-

marginal and first posterior marginal cells, covers the bases of the second and third posterior marginal, and about three-quarters of the fourth posterior marginal. The first posterior marginal is brown at the base and along the vein separating it from the anal cell which is also slightly clouded. The brown of the costal margin widens beyond the stigma into the apical spot covering the marginal cell and the apex of the wing including about one-half of the second sub-marginal cell.

Abdomen :—Tergite 1 yellow at sides with a brown quadrilateral figure just beneath the scutellum, the sides converging toward the posterior margin. Tergite 2 with yellow sides and a large median horse-shoe figure which encloses a light triangle. Tergites 3–5 with yellow sides, light posterior margins and median triangles. The black on the anterior margin of the tergites is in the form of two semicircular spots, fused at their bases. Tergites 6–7 black on the anterior two-thirds, yellow on the posterior one-third. Venter yellow with vertical black lines on either side of sternites 2–3, and median spots on sternites 3–5. Sternites 6–7 black with yellow posterior margins. Abdomen clothed with yellow hair mixed with silky black on the dark areas.

*Male.* Similar to female. Basal cells of wings more infuscated, and brown predominant in the abdominal pattern.

Distribution :—New York to Minnesota, Ontario to Florida.

#### Group VI. *Vittatus*

##### I. Abdomen brown or grayish-black, without any bright markings.

Small species.

- A. Abdomen grayish-black with dull brown spots. Hyaline triangle of wing extending across the 2nd longitudinal vein.

*fuliginosus* Wied.

- AA. Pure glossy brown species. Hyaline triangle of wing not reaching across the 2nd longitudinal vein ..... *parvulus* Daecke.

##### II. Abdomen always bicolored, shades of black and yellow in varying degrees and proportions.

- A. Abdomen mostly dark, with pale yellow spots and stripes.

- B. Tergites 1–3 of abdomen with a fine middorsal yellow stripe and common lateral spots ..... *lugens* Wied.

- C. Middorsal line distinct over tergites 1–5.

*obsoletus* Wied.

- AA. Abdomen mostly light, with black or brown spots and stripes.

- B. Hyaline triangle of the wing, between the cross-band and

the apical spot, occupying most of the first three posterior marginal cells.

- C. Black on the abdomen in the form of two longitudinal stripes, confluent on the first tergite, with a row of yellow triangular spots between on the following tergites ..... *indus* O. S.
- CC. Black on the abdomen in the form of median spots on tergites 1-2, ad transverse bars on the following tergites ..... *frigidus* O. S.
- D. Abdomen bright yellow with narrow vertical black stripes on each tergite.
- E. Thorax with greenish-yellow longitudinal stripes on dorsum. Fifth posterior marginal cell of wing invaded by the brown of the cross-band ..... *vittatus* Wied.
- EE. Thorax with dull green longitudinal stripes on the dorsum. Fifth posterior marginal cell hyaline ..... *striatus* O. S.
- BB. Apical spot of wing covering the entire apical angle, hyaline triangle confined to the distal  $\frac{1}{3}$  of the second and third posterior marginal cells only.
- C. Abdominal pattern consists of two dark-brown longitudinal stripes bordering on a median yellow stripe.  
..... *univittatus* Macq.
- CC. Abdominal tergite 1 bright yellow, 2-4 each with four vertical narrow black stripes ..... *mæchus* O. S.

### *Chrysops indus*, O.-S.

(*Chrysops indus*, Osten-Sacken, Memoirs of the Boston Society of Natural History, II, 383, 1875.)

Length 7.5-9.5 mm., antennæ 2.2.5 mm., wings 7.5-9 mm. long, 2.5-3 mm. wide.

*Female*. Thorax greenish-yellow with brown longitudinal stripes. Abdomen black with yellow lateral spots and a mid-dorsal series of triangles.

Head:—Face covered with yellow pollen and gray hair. Facial callosities and cheeks reddish-yellow with a greenish lustre on the sides. Frontal callosity black. Ocellar area black bearing three reddish-brown ocelli. Front above the callosity and vertex clothed with greenish-gray pollen and delicate, scattered, yellow hair. Antennæ slender; joint 1 yellow, 2 brown on the outer surface, both beset with small black bristles. Joint 3 reddish at base, the remainder and the terminal style black.



**Thorax:**—The narrow median brown stripe separates two broad greenish-yellow stripes, which are in turn bordered by brown longitudinal stripes. Sides yellow. Pleura yellow, separated from the dorsum by a brown line running from humeri to the base of the wing. Dorsum clothed with delicate black hair. Sides and pleurae with yellow hair. Scutellum brown with a greenish lustre. Legs reddish-yellow; tips of front tibiae and tarsi, and ends of the middle and hind tarsi, black.

Wings with a brown anterior margin extending over the first basal cell, and continuous with the apical spot covering the marginal, first submarginal and about three-fourths of the second submarginal cells. Cross-band fills the proximal half of the first posterior marginal cell, about one-third of the second and one-half of the third, and the entire forth posterior marginal cell. The discal cell is brown except for a hyaline space at the base, the 5th posterior marginal cell is clouded except at the base and margin, and the anal cell is infuscated on the apical one-third. The hyaline triangle is grayish and reaches just across the branching of the third longitudinal vein. A small apical spot on the first basal cell, the second basal cell, a marginal band on the fourth posterior, a similar band on both ends of the fifth posterior, the proximal two-thirds of the anal and the axillary cells, are hyaline.

**Abdomen:**—Tergite 1 yellow with a median square black spot, the width of the scutellum; tergite 2 yellow with a black figure of the same width, and contiguous with that of the preceding segment, enclosing a yellow triangle on the posterior margin. Tergites 3–4 each with two broad black spots which do not reach the posterior margins. The space between the black spots forms a yellow median stripe continuous with the yellow triangle or tergite 2, and faintly tapers into the black tergite 5. Tergites 6–7 black with light posterior margins. Venter reddish-yellow with narrow vertical black lines on the sides of sternites 2–3. The others are black with light posterior margins.

*Male.* Similar to female but darker in color, and the second basal cell as well as the entire anal cell infuscated.

**Distribution:**—Quebec and Ontario to New York and Iowa.

*Chrysops lugens*, Wed.

(*Chrysops lugens*, Wiedemann, *Diptera exotica*, I: 109, 1821.)

Length 7.5–8 mm., antennæ 2–2.5 mm., wings 7–7.5 mm. long, 2–2.3 mm. wide.

*Female*. General appearance dull brown. Thorax gray above, brown on sides. Abdomen dusty brown with an abbreviated, narrow, median, longitudinal, yellow stripe. Wings sub-hyaline with brown picture.

Head:—Face covered with yellow pollen. Facial callosities black. Cheeks yellow around the oral margin, black on the sides. Frontal callosity dull black. Front above the callosity black, covered with grayish-green pollen. Ocellar area lustrous black, bearing three reddish brown ocelli. Antennæ slender, joint 1 dark yellow, joint 2 brown, furrowed, beset with black bristles, joint 3 sinuated at the base, black.

Thorax:—Lacking the usual alternating of longitudinal stripes. The mid-dorsum is greenish, the sides are shining brown. At the base of the thorax, just beneath the vertex, is a ring of deep green. Scutellum reddish yellow. Pleura yellow, clothed with pale yellow hair. Legs yellow, with dark front tarsi and basal tips of middle and hind tibiæ.

Wings brown at base and on the entire costal margin including the costal, sub-costal, and first basal cells. The infuscation widens beyond the stigma to form a broad apical spot covering the marginal, first submarginal and three-fourths of the second submarginal cells. Cross-band extends with its convex posterior border over the basal one-half of the first and second, and three-fourths of the third posterior marginal cells. The discal and fourth posterior marginal cells are brown. The hyaline triangle is very small. The second basal, the anal, axillary, and fifth posterior marginal cells are hyaline.

Abdomen:—The brown on tergites 1–3 is divided in the middle by a common longitudinal yellow spot. The sides of tergites 1–2 are sometimes faintly yellow. The other tergites are uniformly brown. Venter brown, with yellow sides on sternites 1–2.

*Male*. Similar to female. Infuscation extends over parts of second basal cell along the vein separating it from the first basal, and over the basal parts of the fifth posterior marginal cell.

Distribution: New York to Florida; Long Island to Ohio.

*Chrysops maechus*, O.-S.

(*Chrysops maechus*, Osten-Sacken, Memoirs Boston Society of Natural History, II: 347, 1876.)

Length 7–8.5 mm., antennæ 2–2.5 mm., wings 7.5–8.5 mm. long, 2.5–3 mm. wide.

*Female.* General color of thorax green with brown longitudinal stripes. Abdomen yellow with narrow brown stripes. Wings hyaline with broad brown anterior margin and apical spot.

Head:—Face covered with golden yellow pollen and yellow hair. Facial callosities and cheeks honey-yellow. Frontal callosity dull black with a brownish upper border. Ocellar area black, bearing three brown ocelli. Pollen above the frontal callosity grayish, vertex with short yellow hair. Antennal joint 1 yellow, 2 darker, both beset with black bristles. Joint 3 reddish at base, the rest and the terminal style black.

Thorax:—The narrow median brown line separates two broad greenish longitudinal stripes which cover most of the dorsum. These are bordered by glossy brown stripes. Sides greenish-yellow. Pleura yellow, separated from the dorsum by a brown stripe running from base of thorax to base of wing, clothed with yellow hair. Legs yellow, bases of the hind femora and all tarsi dark. Scutellum reddish-yellow with a greenish-brown base.

Wings with a brown anterior margin extending over the entire first basal cell. Second basal cell infuscated in the proximal one-quarter. The cross-band is triangular in shape, and extends from the stigma to the posterior margin of the wing across the basal one-third of the second and three-fourths of the third posterior marginal cell. The discal and the fourth posterior marginal cells are entirely brown. The fifth posterior marginal is cloudy along the veins. The apical spot is continuous with the anterior margin and fills the first and second submarginal cells and the first posterior marginal cell. The hyaline triangle is very small and limited to the posterior borders of second and third posterior marginal cells. Most of the second basal and fifth posterior marginal cells, the anal and axillary cells are hyaline.

Abdomen:—Tergite 1 yellow with a faint circular brown spot just beneath the scutellum. Tergite 2 yellow with a median pair of diverging brown stripes, and the rudiments of lateral stripes.

Tergites 3-4 each with two median and two lateral brown stripes, the median ones being broader than the lateral. Tergites 5-7 brown, with faint yellow markings on the anterior border of tergite 5. Venter yellow. Sternites 4-5 with black posterior margins, 6-7 black. Abdomen clothed with short yellow hair.

*Male.* Similar to female. The picture of the wing is more intensely brown and occupies a larger area than in the female. General tone of the thorax darker, although the pattern is the same as in the female.

Distribution :—New York to Georgia, Minnesota and Arkansas.

*Chrysops striatus* O.-S.

(*Chrysops striatus*, Osten-Sacken, Memoirs of the Boston Society of Natural History II: 391, 1875.)

Length 7-9 mm., antennæ 1.5-2.5 mm., wings 7.2-8.5 long, 2.3-3 mm. wide.

*Female.* Thorax with greenish and brown longitudinal stripes. Wings hyaline with brown anterior margin confluent with the apical spot.

Head :—Face covered with yellow pollen and yellow hair. Facial callosities brown, cheeks black. Frontal callosity lustrous black. Ocellar area black, bearing three brown ocelli. Pollen on front and vertex greenish-gray with pale yellow hair. Antennal joint 1 yellow, 2 darker on the outer surface, both beset with black bristles. Joint 3 reddish at the base, the rest and the short terminal style, black.

Thorax :—The narrow median brown line separates two broad greenish-gray longitudinal stripes, which are bordered by brown stripes. Sides light yellow. Pleura yellow, separated from the dorsum by a brown stripe. Legs reddish-yellow, front tarsi, bases of hind femora and the tarsi, dark. Scutellum bluish-black with reddish-yellow apex.

Wings brown on the anterior margin including the entire first basal cell. The apical spot fills the entire first and the terminal half of the second submarginal cells. The cross-band is nearly vertical in its posterior border, and covers the proximal half of the first posterior, one-third of the second posterior, one-half of the third posterior and the entire fourth posterior and discal



cells. The fifth posterior marginal cell is slightly clouded along the veins. The hyaline triangle wedges across the branching of the third longitudinal vein into the first submarginal cell, spreads over the apical parts of the first three posterior marginal cells and the basal two-thirds of the second submarginal cell. The second basal cell, except for a brown spot at the base, the anal, axillary and the fifth posterior cells, are hyaline.

Abdomen:—Tergite 1 reddish-yellow with two median black spots which are fused on the anterior border, just beneath the scutellum. Tergites 2–5 yellow, each with four black longitudinal stripes, which do not reach the posterior margins of the segments. Tergites 6–7 black with yellow posterior margins. Venter yellow on the first two sternites, the others with black median spots and lateral lines.

*Male* similar to female. The infuscation of the wings is more extensive, and involves the second basal cell and the fifth posterior marginal cell. The clear areas are rather cloudy and not hyaline as in the female.

Distribution:—Ontario and Quebec to Mexico; Long Island to Minnesota.

Synonym:—*vittatus* Bellardi, 1859.

*Chrysops univittatus* Macq.

(*Chrysops univittatus*, Macquart, *Diptera Exotica*, Supplement V: 36, 1855.)

Length 6–7.5 mm., antennæ 2–2.5 mm., wings 6.3–7.5 mm. long, 2–2.3 mm. wide.

*Female*. Thorax with alternating brown and green stripes. Abdomen with a narrow median longitudinal yellow stripe, enclosed by two brown stripes. Wings with a brown picture occupying most of the apical part.

Head:—Face covered with pale yellow pollen and delicate yellow hair. Facial callosities shining yellow with circular protuberances on the anterior border which are brownish. Cheeks yellow. Frontal callosity black. Ocellar area black, bearing three brown ocelli. Front and vertex clothed with greenish-gray pollen and gray hair. Antennal joint 1–2 reddish-yellow, beset with short hair. Joint 3 yellow at base, gradually darkening towards the terminal style which is black.

**Thorax:**—The middorsal brown narrow stripe separates between two wide greenish stripes, which in turn are followed by brown stripes. Sides green. Pleura green clothed with short yellow hair. Scutellum brown with a reddish-yellow apex. Legs yellow, front tarsi and tips of the middle and hind tarsi dark. Wings with a brown anterior border extending over the first basal cell. The apical spot covers the first and second submarginal cells except for a small clear area at the branching of the vein, and also invades the apex of the first posterior marginal cell. The cross-band extends in nearly a horizontal line towards the fourth posterior marginal cell which it fills completely, as well as the discal cell. Second basal cell, except for a brown spot at the base, the fifth posterior marginal, anal and axillary cells hyaline. The hyaline triangle wedges slightly across the point of the branching of the third longitudinal vein, and spreads over the middle portion of the first, and the apical parts of the second and third posterior marginal cells. A narrow brown streak interrupts the hyaline triangle in the region of the first posterior cell, connecting the brown base of the cell with its brown apex.

**Abdomen:**—Tergites 1-4 with a common median yellow stripe bordered by broad brown stripes. Sides yellow. The yellow median stripe broadest on the first two tergites, tapering posteriorly. Tergites 5-7 black, without any trace of yellow. Venter brown. Pubescence short, black, and yellow.

**Male** similar to female but darker in tone. The second basal mostly brown.

**Distribution:**—Ontario to Florida, Long Island to Illinois.

**Synonym:**—? *Chrysops fascipennis*, Macquart, 1934.

*Chrysops vittatus* Wied.

(*Chrysops vittatus*, Wiedemann, Diptera Exotica I: 106, 1821.)

Length 7-9 mm., antennæ 2-2.5 mm., wings 7-8.5 mm. long, 2-2.5 mm. wide.

**Female.** Thorax with alternating yellow and brown stripes clearly outlined. Abdomen reddish-yellow with four longitudinal rows of black stripes. Wings with a broad anterior brown margin and infurcated apex separated from the cross-band by a small hyaline triangle.

Head:—Face covered with golden-yellow pollen and pale yellow hair. Facial callosities and cheeks honey yellow. Frontal callosity yellow with a semicircular brown border. Ocellar area black, bearing three brown ocelli. Antennal joints 1-2 reddish-yellow with short black bristles and longer yellow hair. Joint 3 reddish at base, the rest and the terminal style, black. Front with yellow pollen and gray hair.

Thorax:—Middorsal brown stripe separates two wide yellow stripes with a greenish hue on their anterior one-third. These are bordered by lustrous brown stripes. Sides yellow with yellow hair. Pleuræ greenish-yellow, separated from the dorsum by a brown stripe. Legs reddish-yellow. Front tarsi and tips of all tarsi dark. Scutellum reddish-yellow.

Wings with a brown anterior margin extending over the first basal cell. Apical spot covers the first submarginal and two-thirds of the second submarginal cell. Cross-band extends irregularly toward the fourth posterior marginal cell, and fills the proximal half of the first, one-third of the second, obliquely one-half of the third and the whole fourth posterior marginal cells, except for a narrow clear margin. The discal cell and the fifth posterior marginal cells are brown except at the base. The base of the second basal cells and the tip of the anal cell are infuscated, the rest is hyaline. The hyaline triangle wedges across the branching of third longitudinal vein, and spreads over the apical parts of the first three posterior cells, and the proximal one-third of the second submarginal cell. A narrow streak of brown interrupts the hyaline triangle in the middle of the first posterior cell connecting the cross-band with the apical spot in that region.

Abdomen:—Tergite 1 yellow with two faint circular median spots. Tergite 2 yellow with two median and rudiments of two lateral black stripes. Tergites 3-4 yellow, each with four distinct black stripes. Tergite 5 brown with faint indications of division into separate stripes. Tergites 6-7 brown with light posterior borders. Venter reddish-yellow with lateral narrow black lines and brown posterior borders on sternites 2-5. The apical sternites brown. Pubescence short, yellow.

*Male* similar to female. Second basal cell of wing brown, ex-

cept at the very tip. Thorax darker in tone than in the female.

Distribution:—Quebec and Ontario to Florida; Long Island to Kansas.

Synonyms:—*Areolatus*, Walker, 1848.

*lineatus*, Jaennicke, 1868.

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## A LIST OF THE ANTS OF TEXAS

BY M. R. SMITH

DEPARTMENT OF ENTOMOLOGY, MISSISSIPPI STATE COLLEGE, STATE COLLEGE,  
MISSISSIPPI

The ants of Texas are of interest to the formicologist for many reasons. Texas contains many tropical and subtropical species that are not found elsewhere in the United States. The magnitude of the state, with its favorable climatic conditions, is responsible for its having at least twenty to twenty-five percent of all the ants of America, north of Mexico. Furthermore, more ants have been described from Texas than from any other state in the Union. Lastly, it was here that Dr. W. M. Wheeler, our international authority on ants, laid down a large part of the cornerstone of North American formicology.

Preceding Wheeler in the study of the ants of Texas was S. B. Buckley, a geologist, who described sixty-seven species of North American ants among which were a number of Texas forms. Most of these ants have escaped recognition by later workers because of the inadequate descriptions of Buckley. Fortunately Wheeler was able to reestablish many of Buckley's species because of his intimate knowledge of the area and of the habits of the ants. For a review of this subject see Wheeler's, A Consideration of S. B. Buckley's "North American Formicidæ." (Trans. Texas Acad. Sci. Vol. 4, pp. 2-15, 1902).

In 1912 J. D. Mitchell and W. D. Pierce published a list of forty-six species of ants occurring in Victoria county (Proc. Ent. Soc. Washington Vol. 14, pp. 67-76). This list although very small is of interest largely because of the excellent observations made by these men on the habits and biology of the ants.

So far as the writer is aware, Texas is the only state that contains representatives of the seven present subfamilies of ants. Texas has also without doubt more *Ponerinae* and *Dorylinae* than any other state. There is though a particular scarcity of forms in the *Dolichoderinae* and *Formicinae*. Of the fifty-eight genera of ants occurring in America, north of Mexico (including imported forms) the state lacks nineteen genera or approximately one

third. These genera are: *Sysphincta*, *Euponera*, *Bothriomyrmex*, *Dolichoderus*, *Xenomyrmex*, *Epæcus*, *Erebomyrma*, *Sympheidole*, *Epipheidole*, *Stenamma*, *Veromessor*, *Symmyrmica*, *Harpagoxenus*, *Triglyphothrix*, *Wasmannia*, *Cardiocondyla*, *Myrmica*, *Antilæmyrmex*, *Lasius*. It is true that a few of these genera might be expected to have representatives in the state but so far they have escaped detection.

Anyone who contemplates studying the ants of Texas should by all means possess a copy of Wheeler's "The Ants of Texas, New Mexico and Arizona." (Bull. Amer. Mus. Nat. Hist. Vol. 24, pp. 399-485, 1908). Other helpful articles by the same author are in *Psyche*, *The American Naturalist*, *Journal of the New York Entomological Society*, *Bulletin of the Museum of Comparative Zoology* (Harvard) and *Annals of New York Academy of Sciences*. Most of these publications appeared during the years 1900-1910.

It is the writer's opinion that further collecting in the state will raise the number of species recorded in this list (172) to considerably more than 200.

This list represents collections made by individuals whose names are too numerous to mention in this introduction. Proper credit is given them elsewhere in the paper. The Argentine Ant Survey referred to in the list was made by the United States Bureau of Entomology principally in the eastern half of the state. Incidental to the regular scouting work for Argentine ants other species were also collected. Men who took part in this work were: Messrs. D. E. Read, T. F. McGehee, H. T. Vanderford, and L. C. Murphree.

The writer wishes to express here his appreciation of the help given him by Mr. F. F. Bibby of the Texas Agricultural Experiment Station in the study of the ants of Texas.

### Family *FORMICIDÆ*

#### Subfamily *Dorylinæ*

1. *Eciton* (L.) *cæcum* (Latreille). Austin, Ft. Davis (Wheeler), Barksdale (Brown), Dallas (Boll), Schulenberg, Hempstead, Richmond, Goliad, Willis, Saratoga, Waxahatchie, Nacogdoches, Waco, Meridian, Marlin,



Mineral Wells, Stephenville, Weatherford, Houston, Blessing, Port Lavaca, Bloomington, Sinton, Taft, Ranger, Comanche, Lampasas, Smithville, San Antonio, Cameron, Corpus Christi (Argentine Ant Survey), Victoria County (Mitchell and Pierce).

2. **Eciton (L.) esenbecki** (Westwood). Las Borrugas near Brownsville (Wheeler).
3. **Eciton (A.) arizonensis** Wheeler. Brownsville (Schaeffer), Austin (Holliday).
4. **Eciton (A.) commutatum** Emery. Austin (Melander), Shiner, Victoria, Liberty, San Augustine, Jasper (Argentine Ant Survey).
5. **Eciton (A.) harrisi** (Haldeman). Austin (Wheeler), Brownsville (Schaeffer), Dallas (Boll), Rock Island (G. O. Wiley), Victoria County (Mitchell and Pierce).
6. **Eciton (A.) melsheimeri** (Haldeman). Austin (Wheeler), Brownsville (Schaeffer), Plano (Tucker), Dallas (Boll).
7. **Eciton (A.) minor** (Cresson). Bosque County (Belfrage), *type locality*.
8. **Eciton (A.) nigrescens** (Cresson). Bosque County (Belfrage), *type locality*.
9. **Eciton (A.) opacithorax** Emery. Austin (H. Heath), Jacksboro, Eastland (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
10. **Eciton (A.) pauxillum** Wheeler. Austin, and near Alpine (Wheeler) *type localities*.
11. **Eciton (A.) pilosus** F. Smith. Austin, New Braunfels (Wheeler), Dallas (Boll), Colorado County (G. O. Wiley), Ranger, Lockhart, Cameron (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
12. **Eciton (A.) schmitti** Emery. Austin, McNeil, Del Rio (Wheeler), Wharton, Dallas, Cleburne, Carthage, Commerce, West Columbia, Palacios (Argentine Ant Survey).
13. **Eciton (A.) spoliator** Forel. Bosque County (Belfrage).
14. **Eciton (A.) wheeleri** Emery. Hays County (Wheeler) *type locality*. Austin (Wheeler), Hillsboro (Argentine Ant Survey).

15. **Eciton (A.) wheeleri** subsp. **dubia** Creighton. Near Fort Worth (H. Ruckes) *type locality*.

Subfamily *Cerapachyinae*

16. **Cerapachys (P.) augustæ** Wheeler. Austin (A. Rucker) *type locality*.  
17. **Acanthosticus (C.) texanus** Forel. Brownsville (Wickham) *type locality*.

Subfamily *Ponerine*

18. **Stigmatomma pallipes** (Haldeman). Austin (Wheeler).  
19. **Platythyrea punctata** (F. Smith). Brownsville (Wheeler).  
20. **Ectatomma hartmanni** Wheeler. Huntsville (C. G. Hartmann) *type locality*.  
21. **Ectatomma tuberculatum** (Oliver). Imported into the state to control the cotton boll weevil, *Anthonomus grandis* Boh. Colonized in Victoria County in the years 1904-1906.  
22. **Proceratium croceum** (Roger). Texas (Emery).  
23. **Neoponera villosa** (Fabricius). Brownsville (Schaeffer), Alice, Kennedy (Wheeler), Victoria (W. D. Hunter).  
24. **Pachycondyla harpax** subsp. **montezumia** F. Smith. Austin, Del Rio (Wheeler), Barksdale (Brown), Brownsville (Schaeffer), Schulenberg, Houston, Blessing, Taft, San Antonio (Argentine Ant Survey), Victoria County (Mitchell and Pierce).  
25. **Ponera ergatandria** Forel. New Braunfels (Wheeler), Temple (Argentine Ant Survey).  
26. **Ponera inexorata** Wheeler. Austin, San Angelo, Ft. Davis (Wheeler) *type localities*.  
27. **Ponera opaciceps** Mayr. New Braunfels, Granite Mts., Austin (Wheeler), Cleveland, Nederland, Port Neches, Matagorda, San Antonio (Argentine Ant Survey).  
28. **Ponera trigona** var. **opacior** Forel. Austin, McNeil, Marfa (Wheeler), Plano (Tucker), Paris (Rucker), Victoria County (Mitchell and Pierce), Marshall, Commerce, Brownwood, Bryan (Argentine Ant Survey).  
29. **Leptogenys (L.) elongata** (Buckley). Near Austin

- (Buckley) *type locality*. New Braunfels, Belton, (Wheeler), Brenham, Yorktown, Dallas, Waco, Mineral Wells, Beaumont, Port Arthur, Houston, LaPorte, Angleton, Matagorda, Port Lavaca, Refugio, Stanford, Brownwood, Georgetown, Bastrop, San Antonio, Bryan, Robstown, Gatesville (Argentine Ant Survey).
30. **Odontomachus hemotodes** subsp. **clarus** Roger. Austin, San Antonio, Marble Falls, San Angelo, Milano, Alpine, Ft. Davis (Wheeler), Meridian (Long), Eastland County (G. O. Wiley).
31. **Odontomachus hematodes** subsp. **desertorum** Wheeler. Brady, New Braunfels, McAllen, Alice (Argentine Ant Survey).

Subfamily *Pseudomyrminae*

32. **Pseudomyrma brunnea** F. Smith. New Braunfels, Waco (Wheeler), Brownsville (Schaeffer), Victoria County (Mitchell and Pierce), Harlingen, San Benito (Argentine Ant Survey).
33. **Pseudomyrma flavidula** F. Smith. Barksdale (Brown), New Braunfels, Austin (Wheeler), Victoria County (Mitchell and Pierce).
34. **Pseudomyrma gracilis** var. **mexicana** Roger. Brownsville (Schaeffer), Corpus Christi, San Benito (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
35. **Pseudomyrma pallida** F. Smith. Waco, New Braunfels (Wheeler), Brownsville (Schaeffer), Falfurrias, Mercedes (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
36. **Pogonomyrmex apache** Wheeler. Ft. Davis (Wheeler) *type locality*.
37. **Pogonomyrmex barbatus** var. **molefaciens** (Buckley). Central Texas (Buckley) *type locality*. Victoria County (Mitchell and Pierce), Ranger, Elgin, Sweetwater, Sealy, Cuero, Runge, Port Neches, Dallas, Kingsville, Harlingen, Olney, Luling, Abilene, Denton and other localities (Argentine Ant Survey).
38. **Pogonomyrmex barbatus** var. **nigrescens** Wheeler. Eagle

- Pass (Wheeler) *type locality*. Del Rio, Langtry, Toronto, Ft. Davis (Wheeler).
39. **Pogonomyrmex barbatus** var. **marfensis** Wheeler. Marfa (Wheeler) *type locality*. Brewster and Presidio Counties (Wheeler).
40. **Pogonomyrmex californicus** (Buckley). Marfa (Wheeler).
41. **Pogonomyrmex californicus** subsp. **maricopa** Wheeler. Marfa (Wheeler), Barton (J. C. Crawford), Victoria (J. D. Mitchell), Chisos Mts. (Phillips).
42. **Pogonomyrmex comanche** Wheeler. Montopolis (Wheeler) *type locality*.
43. **Pogonomyrmex desertorum** Wheeler. Alamito, San Esteban (Wheeler), *type localities*. Langtry (Wheeler).
44. **Pogonomyrmex sancti-hyacinthi** Wheeler. San Pedro Springs near San Antonio (Wheeler) *type locality*. Ft. Davis (Wheeler).
45. **Pogonomyrmex** (E.) **imberbicus** Wheeler. Mt. Barker near Austin (Wheeler) *type locality*.
46. **Aphaenogaster mutica** Pergande. Terlingua (Wheeler).
47. **Aphaenogaster texana** Emery. Texas (Emery) *type locality*. Austin, New Braunfels (Wheeler), San Antonio (Argentine Ant Survey).
48. **Aphaenogaster texana** var. **carolinensis** Wheeler. Seguin (Argentine Ant Survey).
49. **Novomessor albisetosus** (Mayr). Alamito (Wheeler), Chisos Mts. (Creighton), Ft. Davis Mts. (Wheeler), Presidio (W. C. McDuffie).
50. **Novomessor cockerelli** (Andre). Alpine, Del Rio, Ft. Davis Mts., Stockton, Langtry, Monahans, Terlingua, Toronto (Wheeler), El Paso (J. C. Bradley), Marathon (Creighton), Sierra Blanca, Warfield (Creighton), Midland (Argentine Ant Survey).
51. **Pheidole desertorum** Wheeler. Ft. Davis (Wheeler) *type locality*. Yorktown, Florensville, Kennedy, Runge, Beeville, San Juan, El Paso (Argentine Ant Survey).
52. **Pheidole desertorum** var. **comanche** Wheeler. Paisano Pass and Terlingua (Wheeler) *type localities*. Mathis (Argentine Ant Survey).



53. *Pheidole crassicornis* subsp. *porcula* Wheeler. Chisos Mts. (O. W. Williams) *type locality*.
54. *Pheidole crassicornis porcula* var. *tetra* Wheeler. San Antonio, Austin (Wheeler) *type localities*. Somerville, Brownsville (Argentine Ant Survey).
55. *Pheidole crassicornis* var. *diversipilosa* Wheeler. Ft. Davis (Wheeler) *type locality*. Eastland, Flatonia (Argentine Ant Survey).
56. *Pheidole hyatti* Emery. San Angelo, Marfa (Wheeler), Dublin, Clarkeville, Weatherford, Palestine, Hamilton, Cisco, Midland, Yoakum, Clarksville, Paris, Bonham, Greenville, Collins, Stephenville, Dallas, Marlin (Argentine Ant Survey).
57. *Pheidole hyatti* var. *ecitonodora* Wheeler. Austin and Belton (Wheeler) and Paris (A. Rucker) *type localities*. McKinney (Argentine Ant Survey).
58. *Pheidole texana* Wheeler. Travis County (Wheeler) *type locality*.
59. *Pheidole titanis* Wheeler. Paisano Pass (Wheeler), Chisos Mts. (O. W. Williams) *type localities*.
60. *Pheidole ridicula* Wheeler. Brownsville (C. L. Scott) *type locality*. San Diego (Pergande).
61. *Pheidole dentata* Mayr. Abilene, Richmond, Wichita Falls, Alice, Maud Low, Sinton, and many other localities (Argentine Ant Survey).
62. *Pheidole dentata* var. *commutata* Mayr. Laredo (J. F. McLendon), San Antonio, Brenham, Harlingen, Brownsville (Argentine Ant Survey), Hearne, Denton, Meridian (Long), New Braunfels, Austin, Galveston, Alice, and Granite Mts. (Wheeler).
63. *Pheidole morrissi* var. *impexa* Wheeler. Del Valle near Austin (Wheeler) *type locality*.
64. *Pheidole casta* Wheeler. Langtry (Wheeler) *type locality*.
65. *Pheidole ceres* Wheeler. Ft. Davis (Wheeler).
66. *Pheidole humeralis* Wheeler. Corsicana (M. Cooper) *type locality*.
67. *Pheidole kingi* subsp. *instabilis* Emery. Del Rio (Wheeler), Cisco, Lockhart, San Marcos, Nixon, Mineral Wells, Mathis (Argentine Ant Survey).

68. **Pheidole lamina** Wheeler. Austin (Wheeler) *type locality*.
69. **Pheidole marcidula** Wheeler. Barton Creek near Austin (Wheeler) *type locality*.
70. **Pheidole macclendoni** Wheeler. Laredo (J. F. McClen-don) and Corsicana (M. Cooper) *type localities*.
71. **Pheidole pinealis** Wheeler. Near Ft. Davis (Wheeler) *type locality*.
72. **Pheidole sitarches** Wheeler. New Braunfels, Mt. Barker near Austin (Wheeler) *type localities*. Bridgeport (Argentine Ant Survey).
73. **Pheidole sitarches** var. **transvarians** Wheeler. Mt. Barker near Austin (Wheeler) *type locality*.
74. **Pheidole sitarches** subsp. **rufescens** Wheeler. Bull Creek, Walnut Creek, Mt. Bonnell, Mt. Barker near Austin, San Angelo (Wheeler) *type localities*. Somerville, Shiner, Gonzales, Richmond, Jacksboro (Argentine Ant Survey).
75. **Pheidole sitarches rufescens** var. **campestris** Wheeler. Henrietta (Wheeler) *type locality*.
76. **Pheidole vinelandica** Forel. Austin, Marble Falls, (Wheeler), Luling, Hempstead, San Diego (Argentine Ant Survey).
77. **Pheidole vinelandica** subsp. **longula** Emery. San Angelo, Alice, Henrietta, Austin (Wheeler), Denton (Long), Fort Worth, Gatesville (Argentine Ant Survey).
78. **Pheidole xerophila** Wheeler. Ft. Davis (Wheeler) *type locality*.
79. **Pheidole constipata** Wheeler. New Braunfels (Wheeler) *type locality*.
80. **Pheidole lauta** Wheeler. New Braunfels (Wheeler) *type locality*.
81. **Pheidole metallescens** Emery. Austin, Montopolis, Del Rio, Marble Falls (Wheeler).
82. **Pheidole metallescens** subsp. **splendidula** Wheeler. Austin, Montopolis, Del Valle, Marble Falls, Del Rio (Wheeler), Denton (W. H. Long) *type localities*. Corpus Christi (Argentine Ant Survey).
83. **Pheidole nuculiceps** Wheeler. New Braunfels (Wheeler) *type locality*.

84. **Pheidole sciophila** Wheeler. Austin, New Braunfels (Wheeler) *type localities*.
85. **Crematogaster (O.) arizonensis** Wheeler. Harlingen, San Benito, Brownsville, Mercedes, McAllen (Argentine Ant Survey).
86. **Crematogaster minutissima** Mayr. Texas (Mayr) *type locality*. Austin, New Braunfels (Wheeler), Buna, Houston (Argentine Ant Survey).
87. **Crematogaster (O.) victima** subsp. *missouriensis* Emery. Paris (A. Rucker).
88. **Crematogaster (A.) ashmeadi** Mayr. Denton (Long), Clarksville, Detroit, Sherman, Beaumont (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
89. **Crematogaster (A.) coarctata** var. *mormonum* Emery. Ft. Davis (Wheeler).
90. **Crematogaster (A.) laeviuscula** Mayr. Ft. Cobb (Mayr) *type locality*. Galveston (Wheeler), Wharton, Beaumont, College Station, Corpus Christi (Argentine Ant Survey).
91. **Crematogaster (A.) laeviuscula** var. *clara* Emery. Ft. Cobb (Mayr) *type locality*. San Marcos, Hallettsville, Yoakum, Clarksville, Detroit, Bogato, Honey Grove, Wichita Falls, Houston, Waxahatchie, Llana, Alice, Harlingen, San Benito, Mercedes, San Juan, McAllen, McGregor (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
92. **Crematogaster (A.) opaca** subsp. *depilis* Wheeler. Del Rio (Wheeler), and several localities in New Mexico and Mexico, *type localities*.
93. **Crematogaster opaca depilis** var. *punctulata* Emery. Paris (A. Rucker), Sealy, Mt. Pleasant, Wichita Falls, Nederland, Matagorda, Rockport, Sinton, Dallas, Somerville (Argentine Ant Survey).
94. **Monomorium minimum** Buckley. Central Texas (Buckley) *type locality*. Austin, Ft. Davis (Wheeler), Victoria County (Mitchell and Pierce). Very common and widely distributed over the eastern half of the state where scouting was carried on in the Argentine Ant Survey.

95. **Monomorium pharanois** (Linnaeus). Austin, Galveston (Wheeler), Abilene, Beaumont, Palestine, McAllen (Argentine Ant Survey), Victoria County (Mitchell and Pierce).
96. **Solenopsis geminata** (Fabricius). Austin, New Braunfels, Ft. Davis (Wheeler), Beaumont, Houston, Galveston, Freeport, Aransas Pass, San Marcos, LaGrange, Brenham, Richmond, Yoakum, Llano, Gonzales, San Antonio, Bryan, Harlingen, Brownsville, Edinburg, Gatesville (Argentine Ant Survey). This species is probably confined more to the southern section of the state than elsewhere.
97. **Solenopsis geminata** subsp. *rufa* (Jerdon). Montopolis, Austin, Lampasas (Wheeler), Paris (A. Rucker), Granite Mts. (Long). The writer is of the opinion that the presence of a mesosternal spine on the worker cannot be used to separate this subspecies from *geminata* and for that reason the exact distribution of these two forms is probably not correctly known.
98. **Solenopsis xyloni** McCook. Longview, Athens, Tyler, Corsicana, Jasper, Clarksville, Detroit, Bonham, Denison, Wichita Falls, Weatherford, Port Arthur, Houston, Galveston, Refugio, Sweetwater, Abilene, El Paso, Beeville, Goliad, Victoria, Orange, Ranger, Hearne, Bryan, Corpus Christi and many other localities (Argentine Ant Survey). This species was found to be one of the most common forms of fire ants in the eastern half of Texas where scouting was done.
99. **Solenopsis xyloni** subsp. *aurea* Wheeler. Austin (Wheeler) *type locality*. Ft. Davis (Wheeler).
100. **Solenopsis** (D.) *molesta* (Say). Texas (Mayr).
101. **Solenopsis** (D.) *picta* var. *moerens* Wheeler. Victoria (J. D. Mitchell) *type locality*.
102. **Solenopsis** (D.) *pilosula* Wheeler. Alice (Wheeler) *type locality*.
103. **Solenopsis** (D.) *salina* Wheeler. Ft. Davis (Wheeler) *type locality*.
104. **Solenopsis** (D.) *texana* Emery. Texas (Emery) *type*



- locality*. Austin, Belton, McNeil, Henrietta (Wheeler), Victoria County (Mitchell and Pierce).
105. *Erebomyrma longi* Wheeler. Denton (W. H. Long) *type locality*.
106. *Myrmecina graminicola* subsp. *americana* Emery. New Braunfels, Plano (Tucker).
107. *Myrmecina graminicola americana* var. *brevispinosa* Emery. Austin (Wheeler).
108. *Myrmecina graminicola* subsp. *texana* Wheeler. Shoal Creek, Austin (Wheeler) *type locality*.
109. *Macromischa subditiva* Wheeler. Walnut Creek near Austin and New Braunfels (Wheeler) *type localities*. Victoria (J. D. Mitchell), Harlingen (R. A. Vickery).
110. *Leptothorax fortinodis* Mayr. Austin (Wheeler).
111. *Leptothorax fortinodis* var. *gilva* Wheeler. Austin (Wheeler) *type locality*.
112. *Leptothorax obturator* Wheeler. Austin (Wheeler) *type locality*.
113. *Leptothorax schaumii* Roger. Austin (Wheeler).
114. *Leptothorax texanus* Wheeler. Milano (Wheeler) *type locality*.
115. *Leptothorax terrigena* Wheeler. Austin, McNeil (Wheeler) *type localities*.
116. *Leptothorax* (D.) *pergandei* Emery. Austin, San Angelo, Toronto (Wheeler).
117. *Tetramorium guineense* (Fabricius). Luling, Elgin, San Marcos, Columbus, El Campo, Yoakum, Stockdale, Beeville, Victoria, Buna, Silsbee, Saratoga (Argentine Ant Survey).
118. *Xiphomyrmex spinosus* subsp. *insons* Wheeler. Austin (Wheeler) *type locality*. New Braunfels, Alamito, Alice, San Angelo, Ft. Davis, Kennedy, Langtry, Barksdale, Del Rio (Wheeler).
119. *Cryptocerus texanus* Santschi. Texas (Santschi) *type locality*. Brownsville (Schaeffer).
120. *Strumigenys* (S.) *louisianæ* Roger. Victoria County (Mitchell and Pierce).
121. *Strumigenys* (C.) *margaitæ* Forel. New Braunfels (Wheeler), Comal County (C. F. Baker).

122. **Cyphomyrmex rimosus** var. **comalensis** Wheeler. Comal River, New Braunfels (Wheeler) *type locality*.
123. **Cyphomyrmex wheeleri** Forel. Austin (Wheeler) *type locality*. Belton, Langtry, Ft. Davis (Wheeler).
124. **Trachymyrmex (M.) hartmanni** Wheeler. Montopolis, and Dell Vale near Austin (Wheeler) *type localities*.
125. **Trachymyrmex septentrionalis** subsp. **obscurior** Wheeler. Austin (Wheeler) *type locality*. Montopolis, Milano (Wheeler), Paris (Brues), Denton (Long), Palestine (F. C. Bishopp), Brownwood (Pierce).
126. **Trachymyrmex septentrionalis obscurior** var. **crystallina** Wheeler. Huntsville (C. G. Hartmann) *type locality*.
127. **Trachymyrmex septentrionalis obscurior** var. **irrorata** Wheeler. Huntsville (C. G. Hartmann) *type locality*.
128. **Trachymyrmex turrifex** Wheeler. Austin, Montopolis, Marble Falls, Ft. Stockton, Paisano Pass, Marfa, Del Rio, Langtry (Wheeler) *type localities*. Mercedes, Falfurrias (Argentine Ant Survey).
129. **Trachymyrmex turrifex** subsp. **caroli** Wheeler. Huntsville (C. G. Hartmann) *type locality*.
130. **Atta (M.) versicolor** subsp. **chisonensis** Wheeler. Chisos Mts. (O. W. Williams) and Terlingua (Wheeler) *type localities*.
131. **Atta texana** Buckley. Central Texas (Buckley) *type locality*. Chapel Hill, Brenham, LaGrange, Ye Gua Creek (Linsecum), Alice, New Braunfels, Elgin, Granite Mts. (Wheeler), Llano, Seguin, Columbus, Richmond, Edna, Kennedy, Willis, Kingsville (Argentine Ant Survey), Victoria County (Mitchell and Pierce).

Subfamily *Dolichoderinae*

132. **Liometopum apiculatum** Mayr. Paisano Pass, Ft. Davis (Wheeler).
133. **Iridomyrmex pruinosus** var.  **analis** (Andre). Victoria County (Mitchell and Pierce).
134. **Iridomyrmex humilis** Mayr. Clarksville, Bonham, Gainesville, Henrietta, Wichita Falls, Mineral Wells, Weatherford, Beaumont, Port Neches, Port Arthur, West Port

Arthur, Sabine, Houston, Galveston, Dallas, Lancaster, Fort Worth, Burleson, Ennis, Athens, Tyler, Timpson, Waco, Madisonville, Navasota, Kirbyville, Brenham, Sugarland, Orange, Kountze, Ranger, Comanche, Temple, San Antonio, Taylor.

135. **Forelius foetidus** (Buckley). Central Texas (Buckley) *type locality*. Victoria County (Mitchell and Pierce), Paris, Bonham, Wichita Falls, Mathis, Marshall, Terrell, Kaufman, El Paso, Kingsville, Edinburg, San Juan, Hamilton.
136. **Dorymyrmex pyramicus** (Roger). Victoria County (Mitchell and Pierce), Cameron, Paris, Denton, Bridgeport, Jacksboro, Weatherford, Glen Rose, Bay Town, Mathis, Mineola, Corsicana, El Paso, Bellville, Alice, Edinburg, Gatesville (Argentine Ant Survey).
137. **Dorymyrmex pyramicus** var. **flavus** Pergande. Victoria County (Mitchell and Pierce), Eastland, Smithville, Detroit, Bogata, Mt. Pleasant, Paris, Bonham, Denison, Jacksboro, Burkburnett, Houston, Galveston, Freeport, Angleton, Matagorda, Palacios, Mathis, Midland, Corpus Christi, San Diego, Alice, Falfurrias (Argentine Ant Survey).
138. **Dorymyrmex pyramicus** var. **niger** Pergande. Raymondville (Argentine Ant Survey).
139. **Dorymyrmex pyramicus** var. **bicolor** Wheeler. New Braunfels, Elgin (Wheeler). Presumably one of the *type localities* but not clearly designated by Wheeler as such.

Subfamily *Formicinae*

140. **Brachymyrmex nannellus** Wheeler. Austin (Wheeler) *type locality*.
141. **Camponotus herculeanus** subsp. **pennsylvanicus** (DeGeer). Austin (Wheeler), Beaumont (Long), Victoria (J. D. Mitchell), Dallas (W. D. Hinter), Longview, West Columbia, Huntsville (Argentine Ant Survey).
142. **Camponotus castaneus** subsp. **americanus** Mayr. College Station (F. C. Pratt), Palestine (F. C. Bishopp), Calvert (C. R. Jones).

143. **Camponotus sansabeanus** (Buckley). Austin (Buckley) *type locality*. Marble Falls (Wheeler), Handley (J. C. Crawford), Leary (Pierce), Dallas, Mineral Wells (Argentine Ant Survey).
144. **Camponotus sansabeanus** subsp. **maccooki** Forel. Eastland County (G. O. Wiley).
145. **Camponotus fumidus** var. (**festinatus** Buckley). Central Texas (Buckley) *type locality*. Austin, San Antonio, New Braunfels, San Angelo, Marble Falls, Kenedy, Brownwood, Terlingua (Wheeler), Laredo (McClen-don), Dimmitt County (Schaupp), Chisos Mts. (O. W. Williams), Abilene (A. W. Morrill), Kerrville (F. C. Pratt), Lampasas (W. D. Hunter), Brady (Argentine Ant Survey).
146. **Camponotus fumidus** var. **spurca** Wheeler. Toronto, Paisano Pass, Ft. Davis (Wheeler) *type localities*.
147. **Camponotus abdominalis** subsp. **transvectus** Wheeler. Harlingen, Brownsville (J. D. Mitchell) *type localities*. Mercedes, Edinburg (Argentine Ant Survey).
148. **Camponotus caryæ** subsp. **discolor** (Buckley). Central Texas (Buckley) *type locality*. Austin, Del Valle (Wheeler), Victoria County (Mitchell and Pierce), Wichita Falls, Ranger, Taylor (Argentine Ant Survey).
149. **Camponotus caryæ** subsp. **rasilis** Wheeler. Austin, New Braunfels, Marble Falls, Granite Mts. (Wheeler), Barksdale (Brown), Victoria (W. D. Hunter, J. D. Mitchell), Langtry (Wheeler), Kerrville (Pratt), Llano (J. C. Crawford), Tyler (R. C. Howell) Calvert (C. R. Jones) *presumably type localities in Texas*.
150. **Camponotus caryæ rasilis** var. **pavidus** Wheeler. Victoria (J. D. Mitchell), Dallas (Schwarz, Pratt, Hunter), Calvert (C. R. Jones), Liberty (Tucker), Austin (Wheeler), *no definite locality assigned by Wheeler but presumably his types were from these localities*. Palacios (Argentine Ant Survey).
151. **Camponotus texanus** Wheeler. Travis County (Wheeler) *type locality*. Victoria County (Mitchell and Pierce).



152. **Camponotus (C.) etiolata** Wheeler. Austin (Wheeler) *type locality*. Victoria County (Mitchell and Pierce).
153. **Camponotus (C.) impressus** Roger. Dallas (Schwarz and Pierce).
154. **Camponotus (C.) pylartes** Wheeler. Del Valle (W. D. Hunter) *type locality*. Victoria County (Mitchell and Pierce), Austin, New Braunfels (Wheeler), San Antonio, Taylor (Argentine Ant Survey).
155. **Camponotus (C.) pylartes** var. **hunteri** Wheeler. Victoria (J. D. Mitchell) *type locality*.
156. **Camponotus bruesi** Wheeler. Ft. Davis (Wheeler) *type locality*.
157. **Camponotus planatus** Roger. Brownsville (Schaeffer), Victoria County (Mitchell and Pierce) Port Lavaca, Rockport, Corpus Christi, Harlingen, San Benito, McAllen (Argentine Ant Survey).
158. **Paratrechina longicornis** (Latreille). Dallas, Ft. Worth, Palestine, Corsicana, Waco, Madisonville, Houston, Galveston, Angleton, Aransas Pass, Sinton, San Marcos, LaGrange, Cuero, Luling, Seguin, Austin, Taylor, College Station, Bryan, Corpus Christi, San Diego, Kingsville, Harlingen, San Benito, Brownsville, McAllen (Argentine Ant Survey).
159. **Paratrechina (Nylanderia) bruesi** Wheeler. Fresno Canon, Presidio County (Wheeler) *type locality*.
160. **Paratrechina (Nylanderia) vividula** subsp. **melanderi** Wheeler. San Angelo, Austin, New Braunfels, Ft. Davis (Wheeler) *type localities*. Victoria County (Mitchell and Pierce).
161. **Prenolepis imparis** (Say). Denton (Long), Dallas (Argentine Ant Survey).
162. **Prenolepis imparis** var. **testacea** Emery. Carthage, Dallas (Argentine Ant Survey).
163. **Myrmecocystus melliger** Forel. Brownsville (Langstroth), El Paso (Amer. Mus. Nat. Hist.), Laredo (C. E. Hood), Kenedy (G. P. Goll), Hondo, Cotulla (J. D. Mitchell).

164. **Myrmecocystus melliger** subsp. **mimicus** (Wheeler) Chisos Mts. (W. B. Phillips), Alamito, Langtry, Ft. Stockton, Alpine, Del Rio (Wheeler).
165. **Myrmecocystus melliger mimicus** var. **jesuita** Wheeler. Ft. Davis (Wheeler) *type locality*.
166. **Myrmecocystus melliger mendax** var. **comata** Wheeler. Ft. Davis (Wheeler) *type locality*.
167. **Myrmecocystus melliger** subsp. **orbiceps** Wheeler. Bull Creek near Austin (Wheeler) *type locality*. San Antonio, San Angelo, Langtry, Del Rio (Wheeler), Laredo (McClendon), Victoria (J. D. Mitchell).
168. **Formica pallide fulva** var. **succinea** Wheeler. Austin (Wheeler) *type locality*. Montopolis, Milano, Bee Creek (Wheeler).
169. **Formica pallide fulva schaufussi** var. **dolosa** Wheeler. Bull Creek (Wheeler) *type locality*. Arlington (W. E. Hinds), Edna (J. D. Mitchell).
170. **Formica rufibarbis** var. **gnava** Buckley. Central Texas (Buckley) *type locality*. Austin, Ft. Davis, New Braunfels, Langtry (Wheeler), Llano (A. W. Morrill), Kerrville, Devils River (F. C. Pratt), San Antonio (Argentine Ant Survey).
171. **Formica perpilosa** Wheeler. San Esteban near Marfa, Langtry, Ft. Davis (Wheeler), Eagle Pass (J. D. Mitchell).
172. **Formica sanguinea** subsp. **puberula** Emery. Ft. Davis (Wheeler).

## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF JANUARY 15, 1935

The annual meeting of the Society was held on January 15, 1935 in the American Museum of Natural History. Mr. Bell presided in the absence of Vice-President Schwarz. Thirty members and twenty-four visitors were present.

The treasurer gave an unaudited report for the year 1934. It was referred to the auditing committee.

The Nominating Committee submitted its report and the following officers were elected for 1935.

President .....	Mr. H. F. Schwarz
Vice-President .....	Dr. H. Ruckes
Treasurer .....	Mr. G. C. Hall
Secretary .....	Mrs. Geo. B. Engelhardt
Librarian .....	Mr. F. E. Watson
Curator .....	Mr. A. J. Mutchler

### Executive Committee

Mr. Wm. T. Davis	Dr. F. E. Lutz
Dr. H. Spieth	Mr. Henry Bird

### Publication Committee

Mr. H. B. Weiss	Dr. C. W. Long
Mr. J. D. Sherman Jr.	Dr. C. H. Curran

The following committees had been appointed by the President-elect: Program Committee; A. B. Klots, Harry B. Weiss, J. L. Horsfall. Auditing Committee; E. I. Huntington, F. Johnson, Dr. E. R. P. Janvrin. Field Committee; Herman Moennich and A. S. Nicolay. Delegate to the N. Y. Academy of Sciences, Wm. T. Davis.

In the absence of President Schwarz, Vice-President Ruckes then took the chair.

Dr. R. H. LePelley, the economic entomologist of the Government Experiment Station at Kenya Colony, Africa, was called on to say a few words. Dr. LePelley expressed his pleasure at being present and gave a general description of Kenya Colony, its geography and the climatic of Nairobi. There being no winter season, there is no hibernation of animals. The main crop is coffee which has four or five major pests, the greatest of which is a mealy bug. Kenya suffers greatly from three species of migratory locusts. A large flight of the purple locust, *Locusta migratoria*, has a three mile front and is fifty feet high. This migration is something to be seen by an entomologists as the insects fly at a speed of ten miles an hour and it requires three days for the swarm to pass a certain point. The droppings of such a swarm assume the proportions of a hail storm. When the swarm settles in the forest, the crashing of falling branches and trees may be heard at

some distance as they are broken by the weight of the number of insects alighting on them.

Mr. and Mrs. M. R. Frank of Jackson Heights, New York, were elected active members of the Society.

Dr. G. W. Kidder of the College of the City of New York read his paper on "Cellulose Digestion in Insects and the Question of Microörganism Symbiosis."

Following Dr. Kidder's paper there was a general discussion of its contents by Messrs Asmuth, Moore, Ruckes, Klots, Hamilton, and Tompkins.

ELIZABETH S. ENGELHARDT, *Secretary*.

#### MEETING OF FEBRUARY 5, 1935

A regular meeting of the Society was held on February 5, 1935, in the American Museum of Natural History; Vice-President Ruckes in the chair with nineteen members and sixteen visitors present.

Mr. C. D. Vreeland of Little Falls, New Jersey, was proposed for active membership in the Society by Miss Dobroscky.

Dr. Alfred F. Huettner of New York University read his paper on the "Life History of *Miastor americana*." Dr. Huettner illustrated his remarks with lantern slides. An abstract of this paper will appear in the Proceedings of the Society.

Dr. Huettner's interesting paper was discussed at some length by Messrs. Ruckes, Felt, Curran, Klots, Crawford and others.

E. S. ENGELHARDT, *Secretary*.

#### MEETING OF FEBRUARY 19, 1935

A regular meeting of the Society was held on February 19, 1935, in the American Museum of Natural History; Vice-President Ruckes in the chair with twenty-two members and seventeen visitors present.

Mr. C. D. Vreeland was elected a member of the Society.

Dr. Ralph Voris of State Teachers College, Springfield, Missouri, and Mr. Max Kisliuk, Jr., 844 Federal Building, Christopher Street, New York City, were proposed for active membership in the Society.

Upon motion duly seconded the By-Laws were suspended and Mr. Kisliuk was elected a member of the Society.

Dr. Loren B. Smith of the Chipman Chemical Company read his paper on "Recent Trends in the Control of Plant Pests." Dr. Smith gave the history of the use of insecticides in this country beginning with the year 1850 when the Colorado potato beetle began to spread eastward and a paint company found that it had a compound known as Paris green which would kill these insects. Lead arsenate was first used in Connecticut in 1890 in attempts to control the Gypsy moth. The insoluble arsenites such as lead arsenate, calcium arsenate and Paris green are stomach poisons. The soluble arsenical, sodium arsenate, is used in grasshopper control. The contact poisons such as nicotine, soaps, and lime sulphur are widely used. Tar oil washes and cresylic acid (used in aphid control) are not for general and indiscriminate use. The value of tar oil washes is still an open question. Dr. Smith men-



tioned pyrethrum as an age-old insecticide which has come again into use within the last two decades. In closing, Dr. Smith declared that, in his opinion, the future of the development of insecticides is not very hopeful, as an insecticide that saves the plant or fruit may be detrimental to the consumer; also, that progress along investigational lines is bound to be slow; and finally, up to the present time there has been too much experimenting with chemicals and not enough research.

Dr. Smith's paper was discussed by Messrs. Ruckes, Curran, Moore, Kisliuk, Hartzell, Crawford, Safo, and Vreeland.

Mr. Safo said, in part, that there were men present who had made insecticide history. He mentioned Dr. Smith's wide and exhaustive work; Dr. Vreeland's patent for the manufacture of dry arsenate of lead; and Dr. Hartzell's work on the action of contact insecticides.

E. S. ENGELHARDT, *Secretary*.

#### MEETING OF MARCH 5, 1935

A regular meeting of the Society was held on March 5, 1935, in the American Museum of Natural History; Vice-President Ruckes in the chair with twenty-seven members and twenty visitors present.

Dr. Ralph Voris of State Teachers College, Springfield, Missouri, was elected an active member of the Society.

The following were proposed for active membership:

Mr. William Procter,  
430 Park Ave.,  
New York, N. Y.

Miss Marjorie Schwarz  
1111 Park Ave.,  
New York, N. Y.

The Society was honored in having Mr. and Mrs. Pallister of Cleveland present at the meeting.

Dr. R. W. Glaser of the Rockefeller Institute for Medical Research at Princeton, New Jersey, gave the paper of the evening entitled "Neoaplectana glaseri (Oxyuridae,) a Nematode Parasite of the Japanese Beetle." Dr. Glaser illustrated his remarks with lantern slides. An abstract of his paper follows:

The life cycle of a new nematode parasite of Japanese beetle grubs was described and its method of invasion into and effect upon the insects studied. The nematodes develop well on a special artificial medium and produce from 21 to 31 generations over a period of from 16 to 18 weeks. Both small and large parasite introduction experiments with cultures were performed in southern New Jersey. The nematodes became established, spread over and beyond the experimental area, and produced a high mortality among Japanese beetle grubs. The field work was done in a quantitative manner and the results were treated statistically, so that a fairly accurate appraisal of the effect of the parasite was possible.

Dr. Stunkard of New York University discussed Dr. Glaser's paper; also Dr. Henry Fox, Mr. Safo, Dr. Klots, Miss Dobrosky, and Dr. Ruckes.

ELIZABETH S. ENGELHART, *Secretary*.

## MEETING OF MARCH 19, 1935

A regular meeting of the Society was held on March 19, 1935, in the American Museum of Natural History; President Schwarz in the chair with twenty-six members and thirty-seven visitors present.

The following were elected active members of the Society:

Mr. William Procter,  
430 Park Ave.,  
New York, N. Y.

Miss Marjorie Schwarz  
1111 Park Ave.,  
New York, N. Y.

Mr. Max Kisliuk, Jr., of the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, then gave the talk of the evening on "Some Experiences in Foreign Countries Surveying for Plant Pests especially Fruit Flies." Mr. Kisliuk described his first search for fruit flies in the grapes and tomatoes being shipped to this country in 1927, when he made an extensive survey of the province of Almeria in southern Spain, and also of the Canary Islands. In 1931-32, he made a final tour through the West Indies, down the Eastern coast of South America across Argentina, and up the western coast of Chile, in the company of C. E. Cooley of same Bureau as Mr. Kisliuk.

Mr. Kisliuk illustrated his interesting talk with lantern slides.

ELIZABETH S. ENGELHART, *Secretary*.

## MEETING OF APRIL 2, 1935

A regular meeting of the Society was held on April 2, 1935, in the American Museum of Natural History; President Schwarz in the chair with twenty-one members and fourteen visitors present.

Mr. Frances McGuigan, of 162 Fairview Ave., Jersey City, New Jersey, was proposed for active membership in the Society.

Mr. A. C. Scott of the Department of Zoology of Columbia University gave the talk of the evening entitled "Peculiarities in the Life History and Development of a Pædogenetic Beetle. (*Micromalthus debilis* LeC.)"

Mr. Scott illustrated his remarks with lantern slides.

After a general discussion of Mr. Scott's paper the meeting was adjourned.

ELIZABETH S. ENGELHART, *Secretary*.

## MEETING OF APRIL 16TH, 1935

A regular meeting of the Society was held on April 16th, 1935, in the American Museum of Natural History; President Schwarz in the chair with twenty-nine members and eighteen visitors present.

Mr. Frances McGuigan, of New York City, was elected an active member of the Society.

Dr. J. L. King, of the U. S. D. A., Bureau of Entomology and Plant Quarantine at Moorestown, New Jersey, read his paper on the "Present Status of the Parasites of the Japanese Beetle." Dr. King led an expedition to Japan to ascertain how the insect was kept in check there. However, the beetle was traced with difficulty, although Dr. Kuwana, the Imperial Entomologist of Japan, made every effort to help find infestations. In Japan, the beetle, a pest on soy bean, is known as the bean beetle. Infestations and parasites were found at Sapporo in Hokkaido. Three tachinid parasites were abundant in Japan but did not react favorably to the climate of North America. The hymenopterous parasites, *Tiphia popilliavora*, *T. autumnalis*, and *T. vernalis* were reared and imported successfully into this country. On Dr. King's return to America in 1924, his work in Japan was extended through China and northern India. Since then, twenty-four species of insects parasitic on the Japanese Beetle in the Orient have been imported to America; of these only sixteen species have been reared and liberated; only five species have been established successfully. Dr. King spoke of the development in method and equipment used to rear and spread these parasites in this country. With the spread of the beetle in this country, it is hoped that parasites can be established. Slides illustrating the liberation of colonies of *Tiphia* and the methods and equipment used in importing and rearing the parasites were shown.

A general discussion of Dr. King's interesting paper followed.

ELIZABETH S. ENGELHART, *Secretary*.

#### MEETING OF MAY 7, 1935

A regular meeting of the Society was held on May 7, 1935, in the American Museum of Natural History; President Schwarz in the chair with nineteen members and seven visitors present.

Mr. George Rowe, of the New York Botanical Gardens issued an invitation to the members of the Society to visit the Botanical Gardens on Saturday, May 18, in order to inspect the tropical scale insects to be found in the green-houses. As it was impossible to announce this invitation in the Bulletin, it was decided to postpone this trip until the fall when it was hoped that more members could take advantage of it.

Dr. Henry Fox, of New York University, gave some remarks on the "Spread of the Japanese Beetle in the United States." He described the two methods of distribution: one by the natural spread of the insect through flight from Riverton, New Jersey; and the other, an artificial means in motor vehicles and railroad cars. Slides were shown illustrating the area of continuous distribution from Riverton by natural spread; and the area of discontinuous distribution established by means of artificial conveyances. Maps showing the distribution in 1919 and the spread for the years 1925-1934 were also shown. The natural rate of spread of the insect is very slow. Dr. Fox stated that the favorable conditions to breeding were found in low-lying, level country where the land is cultivated. Dr. Fox then gave a short discussion concerning the future spread of the insect.

ELIZABETH S. ENGELHART, *Secretary*.





# The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943.

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

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WILLIAM T. DAVIS

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of the

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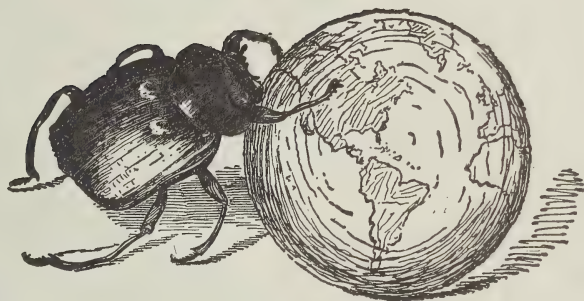
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Devoted to Entomology in General



Edited by HARRY B. WEISS

### *Publication Committee*

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# JOURNAL

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## New York Entomological Society

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### ADDITIONS TO THE NEW YORK STATE LIST OF APHIDS WITH NOTES ON OTHER NEW YORK SPECIES

BY MORTIMER D. LEONARD  
NEW YORK, N. Y.

In "A List of the Insects of New York" (Cornell Univ. Agr. Exp. Sta. Mem. 101, pp. 184-192, 1928) 128 species of the family Aphidæ are recorded as known definitely to occur in the State. Since the fall of 1932 the writer and Prof. C. R. Crosby of Cornell University have collected aphids, as time and opportunity permitted, in several parts of the state, and Mr. F. S. Blanton of the United States Bureau of Entomology has also done some collecting on Long Island.

The following list of 42 species and one variety are additions to the previously published list. Dr. A. N. Tissot of the Agricultural Experiment Station at Gainesville, Florida, has made, or verified, all the determinations of these additional species as well as of all the other species collected by us during the past three years. He has also made several slides of each and our thanks are due him for all his painstaking work on the rather considerable amount of material represented. Several members of the Department of Botany, Cornell University, have kindly made plant determinations.

If the synonymy is correct a total of 171 species of plant lice are now known to occur in New York but around 300 would be more nearly the probable total, judging from its geographic location and rich flora. It is hoped to considerably increase the size

of the present list by more intensive and better planned collecting during the next few years.

The slides upon which the information in this paper is based are in the collection of the author, that of Cornell University and of Dr. A. N. Tissot of the Florida Agricultural Experiment Station, Gainesville, Florida.

#### ADDITIONS TO THE NEW YORK LIST

**Anoecia corni** (Fab.). Ithaca, Oct. 4, 1932 (Crosby), on *Cornus amomum*; Aug. 12 and Sept. 3, 1933 on *Cornus* sp., Sept. 18, 1934 on *C. stolonifera* (Leonard & Crosby), Sept. 24, 1933, adrift in spider web (Crosby), Oct. 5, 1933 on *Cornus* sp. (W. E. Blauvelt), Sept. 27, 1933 on Forsythia, probably drifts—all alates (Crosby), Sept. 4, 1933 on roots of *Dactylis glomerata*—all apteræ (Leonard & Crosby). West Danby, Oct. 9, 1932 (Leonard & Crosby) on *C. amomum*, apteræ. Etna, Sept. 30, 1933 (Crosby) on *Cornus* sp., Oct. 16, 1932 (Leonard & Crosby) on *C. stolonifera*. McLean, Sept. 15, 1934 (Leonard & Crosby) on *Cornus* sp. Taughannock, Sept. 4, 1933 (Leonard & Crosby) on *Cornus* sp. Cayuta Lake, Sept. 13, 1934 (Leonard & Crosby) on *Cornus* sp. Barrington, Sept. 19, 1934 (Leonard & Crosby) on *Cornus* sp. Batavia, Sept. 11, 1934 (Leonard & Crosby) on *Cornus* sp.

**Aphis (Anuraphis) bakeri** Cowen. East Aurora, Aug. 10, 1933 (Crosby & Leonard) on clover. Ithaca, Oct. 24, 1932 (Leonard) on apple leaves (all alates). Delwood, L. I., July 28, 1933 (Leonard) on clover.

**A. cornifoliæ** Fitch. East Aurora, Aug. 10, 1933 (Crosby & Leonard) on *Cornus* sp. Barrington, Sept. 9, 1934 (Leonard & Crosby) on *C. candidissima*.

**A. decepta** H. & F. McLean, Sept. 15, 1934 (Leonard & Crosby) a "drift" on *Cornus* sp.

**A. hederæ** Kalt. Babylon, L. I., May 7, 1932 and June 1933 (Blanton) on English ivy.

**A. laburni** Kalt. Riverhead, L. I., July 20, 1933 (Leonard) common on Lima beans.

**A. maculatæ** Oest. Ithaca, Aug. 12, 1933 (Leonard & Crosby) on poplar leaves and shoots.

**A. (?)middletoni** Thos. Ithaca, Aug. 7, 1933 (Leonard) on roots of Phlox, all specimens immature, determination somewhat doubtful.

**A. œstlundii** Gill. Forest Home, Ithaca, Sept. 4, 1934 (Leonard & Crosby) on *Oenothera* sp. Taughannock, Sept. 4, 1933 (Leonard & Crosby) on *Oe. biennis*.

**A. rhamni** Fonsc. Ithaca, Sept. 18, 1934 (Leonard & Crosby) on *Rhamnus cathartica*. Ringwood, Tompkins Co., Sept. 10, 1934, (Leonard & Crosby) on *Epilobium coloratum*. Cayuta Lake, Sept. 13, 1934 (Leonard & Crosby) alates only on Crataegus leaves. Crosby, Sept. 13, 1934 (Leonard & Crosby) on *Oenothera biennis*. Barrington, Sept. 19, 1934 (Crosby) alates only on Crataegus leaves. Bating Hollow, L. I. (Wildwood State Park), L. I., July 23, 1933 (M. D. & D. P. Leonard), a number of alates only taken singly on leaves of catbrier (*Smilax*). Riverhead, L. I., July 21, 1933 (Leonard) on *Nepeta cataria*.

**A. rumexicolens** Patch. Babylon, L. I., May 23, 1933 (Blanton) on Rumex.

**A. sambucifolii** Fitch. Ithaca, Sept. 13, 1933 (Crosby) and Sept. 18, 1934 (Leonard & Crosby) on *Sambucus canadensis*.

**A. solidaginifoliae** Wms. Ithaca, Aug. 13, 1933 (Leonard & Crosby) on Solidago.

**Cerosiphia rubifolii** (Thos.). Ithaca, Aug. 6, 1933 (Leonard), badly curling blackberry leaves. Riverhead, L. I., July 7, 1933 (Leonard), bad curling of blackberry leaves in a good sized patch.

**Hyalopterus dactylidis** Hayhurst. Babylon, L. I., May 23, 1933 (Blanton) on Panicum.

**Rholalosiphum enigmæ** H. & F. Riverhead, L. I., July 22, 1933 (Leonard) on *Typha latifolia*.

**R. melliferum** (Hottes). Ithaca, Sept. 14, 1934 (Leonard & Crosby) on *Cicuta aculata* and Oct. 21, 1932 (Leonard) on *Symphoricarpos racemosus*. Forest Home, Ithaca (Leonard & Crosby) Aug. 4, 1933 on wild parsnip.

**R. nymphææ** (L.). Rochester, Aug. 11, 1933 (Leonard & Crosby) very abundant on a large collection of water-lilies.

**Drepanaphis monelli** (Davis) McLean, Sept. 15, 1934 (Leonard & Crosby) on hard maple, oviparous females present.

Crosby, Sept. 10, 1934 (Leonard & Crosby), on milkweed, probably a "drift."

**Monellia caryæ** (Mon.). Poughkeepsie, Aug. 1, 1933 (Leonard) moderately common on leaves of black walnut.

**M. nigropunctata** Granovsky. Ithaca, Sept. 13, 1933 (Crosby) on hickory. Eggleston's Glen, Sept. 13, 1934 (Leonard & Crosby) on shagbark hickory. Montauk, L. I., July 30, 1933 (Leonard) on hickory.

**Myzocallis coryli** (Goeze). Ithaca, Sept. 26, 1933 (Wm. E. Blauvelt) on Corylus.

**M. tiliaë** (L.). Brooksville, Aug. 10, 1934 (Crosby) on linden. Riverhead, L. I., Sept. 9, 1934 (Leonard & Crosby) on oak leaves, probably a "drift."

**Stegophylla quercicola** (Baker). Ithaca, Sept. 22, 1934 (Leonard & Crosby) on *Quercus alba*.

**Amphorophora cratægi** (Mon.). Ithaca, Sept. 18, 1934, host unrecorded; Cayuta Lake, Sept. 13, 1934, on *Cratægus* leaves, oviparous females present; Barrington, Sept. 19, 1934, on *Cratægus* (all by Leonard & Crosby).

**A. sensoriata** Mason. Ithaca, Aug. 12, 1933, and Sept. 9, 1934 (Leonard & Crosby) on wild raspberry canes. Freeville, Sept. 15, 1934 (Leonard & Crosby) on wild raspberry canes. Ringwood, Tompkins Co., Sept. 24, 1933 (Crosby) on wild raspberry. Riverhead, L. I., July 22, 1933 (Leonard) on raspberry.

**A. sonchi** (Oest.) (= *A. cosmopolitana* Mason). Ithaca, Sept. 9, 1933 (Crosby) on *Lactuca canadensis*; Sept. 17, 1934 (Leonard) on *Sonchus asper*; Oct. 9, 1932 (Leonard & Crosby) on currant.

**Capitophorus flaveolus** (Walk.). Wallace, Sept. 10, 1933 (collector ?) on thistle.

**C. gillettei** Theob. Etna, Sept. 30, 1933 (Crosby) on Polygonum.

**Macrosiphum ambrosiæ** (Thos.). Ithaca, Sept. 3, 1933 (Crosby) on Solidago; Sept. 9, 1933 (Crosby) on Arctotis and Lactuca; Sept. 19, 1933 (Crosby) on Arctotis; Sept. 13, 1934, on *Aster puniceus*; Sept. 14, 1934, on *Eupatorium urticæfolium*; Sept. 15, 1934, on *Lactuca* sp.; Sept. 18, 1934, on *Lactuca spicata* (these latter with cornicles, almost too long for *M. am-*



*brosiae*) ; Oct. 20, 1932 (Leonard) on *Calendula*, all collected by Leonard and Crosby. McLean, Sept. 15, 1934 (Leonard & Crosby) on Joe Pye weed, *Eupatorium* sp. (viviparous females and at least one male present.) Ringwood, Tompkins Co., Sept. 10, 1934 (Leonard & Crosby) on *Aster umbellatus*, *Lactuca* sp. and Everlasting. Babylon, L. I., Aug. 25, 1933, on ragweed and Aug. 30, 1934, on *Lactuca canadensis* (F. S. Blanton).

**M. (?) anomalæ** H. & F. Ithaca, Sept. 29, 1933 (Crosby) on *Aster nova-angliae*.

**M. erigeronensis** (Thos.). Taughannock, Sept. 4, 1933 (Leonard & Crosby) on *Erigeron* sp. Egleston's Glen, Sept. 12, 1934 (Leonard & Crosby) on *Erigeron canadensis*. Riverhead, L. I., July 24, 1933 (Leonard) on *Erigeron* sp.

**M. gravicornis** Patch. Batavia, Sept. 14, 1934 (Leonard & Crosby) on *Arctium lappa*. Ithaca, Sept. 14, 1934 (Leonard & Crosby) on *Erigeron annuus*. Babylon, L. I., Aug. 26, 1934 (F. S. Blanton) on Solidago. Dix Hills, L. I., July 11, 1934 (F. S. Blanton) on *Erigeron ramosus*. Riverhead, L. I., July 21, 1933 (Leonard) on *Erigeron canadensis*, and July 29, 1933 (Leonard & Crosby) on *Erigeron* sp.

**M. illini** H. & F. Ithaca, Sept. 9, 1933 (Crosby) on *Helianthus annuus*. Babylon, L. I., July 8, 1934 (F. S. Blanton) on sunflower leaves.

**M. illini** var. **sangamonensis** H. & F. Ithaca, Sept. 3, 1933 (Leonard & Crosby) on *Helianthus*.

**M. impatiensicolens** Patch. Ithaca, Sept. 3 and 14, 1934 (Leonard & Crosby) on *Impatiens* sp.

**M. pseudorosæ** Patch. Egleston's Glen, Sept. 12, 1934 (Leonard & Crosby) on Boneset, *Eupatorium perfoliatum*. Crosby, Sept. 13, 1934 (Leonard & Crosby) on *Oenothera biennis*. Taughannock, Sept. 4, 1933 (Leonard & Crosby) on *Impatiens* sp.

**M. sonchellum** (Mon.). Riverhead, L. I., July 27, 1933 (Leonard & Crosby) on *Lactuca* sp.

**M. taraxici** (Kalt.). Babylon, L. I., June, 1933 (F. S. Blanton) on *Taraxicum officinale*.

**M. tiliaë** (Mon.). Forest Home, Ithaca, Sept. 14, 1934 (Leonard & Crosby) on basswood.

**Myzus (Kakimia) cynosbati** (Oest.). Ithaca, Oct. 9, 1932 (Leonard & Crosby) on currant.

**Erisoma crataegi** (Oest.). Batavia, Sept. 11, 1934 (Leonard & Crosby) abundant on *Cratægus*. Barrington, Sept. 18, 1934 (Leonard & Crosby) abundant on *Cratægus*. Ithaca, Sept. 15, 1933 (Crosby) on *Cratægus*.

**Prociphilus erigeronensis** (Thos.). Campbell, Aug. 28, 1934 (May Willard) on *Oenothera* sp.

#### NOTES ON OTHER NEW YORK SPECIES

Although already recorded in the New York List as occurring in the State further notes are given for the following species where important extensions of distribution or additional host-plant records have been made in the State.

**Longistigma caryæ** (Harris). Previously listed only from S. Byron. Letchworth Park, June 2, 1933 (H. Dietrich) flying. Locust Valley, L. I., Sept. 1, 1934 (K. E. Maxwell) on birch. Babylon, L. I., July 18, 1934 (F. S. Blanton) on twigs of a dead maple. Floral Park, L. I., Oct., 1934 (Robert T. Ennis) on sycamore to Crosby, specimens destroyed.

**Chaitophorus populifoliæ** Oest. Previously listed only from Ithaca, now also recorded from: Monterey, Schuyler Co., Sept. 19, 1934 (Leonard & Crosby), on poplar; both viviparous females and males present. Amenia, Sept. 27, 1934 (Leonard), males only collected, on poplar.

**C. viminalis** Mon. Previously listed only from Geneva, now also recorded from: Ithaca, Aug. 6, 1933 (Leonard & Forbes) on *Salix* sp. Crosby, Sept. 13, 1934 (Leonard & Crosby) very abundant on basket willow. Freeville, Oct. 16, 1932 (Leonard & Crosby) on leaves of *Salix* sp.

**Clavigerus smithiæ** (Mon.). Recorded previously only from Long Island. We have found it to be very common at Ithaca, Varna, Aetna, Ringwood and Freeville in Tompkins County, Crosby, Williamsville, and Amenia as well in Erie County on the twigs and stems of *Salix alba* and other willows.

**Periphyllus populicola** (Thos.). Tupper Lake, Sept. 6, 1933 (H. Dietrich) on poplar is the first definite record for the Adirondack Mountain region.

**Aphis asclepiadis** Fitch. Previously recorded only from Sheridan and Geneva. East Aurora, Aug. 10, 1933, and Ithaca, Aug. 12, 1933 (Leonard and Crosby) on milkweed.

**A. cephalanthi** Thos. Previously recorded only from Long Island. Crosby, Sept. 13, 1934 (Leonard), and doubtfully at Taughannock, Sept. 4, 1933 (Leonard & Crosby) from *Impatiens* sp. which is a new host plant in the state.

**A. coreopsidis** (Thos.). Previously recorded only from Sheridan and from Maspeth, Long Island. Ithaca, Sept. 4, 1933 (Leonard & Crosby) on *Bidens* sp.

**A. cratægifoliae** Fitch. Previously recorded only from Sheridan; now also from: Ithaca, Oct. 19, 1932 (Leonard) and Sept. 18, 1934 (Leonard & Crosby). Barrington, Sept. 19, 1934, Cayuta Lake, Sept. 13, 1934, and Freeville, Oct. 10, 1932 (all Leonard & Crosby) on leaves of *Cratægus*.

**A. maidis-radicis** Forbes. Previously recorded only from Albany on aster; we add Ithaca, Aug. 12, 1933 (Leonard & Crosby) on roots of yellow sweet clover.

**A. maidis** Fitch. Recorded in the N. Y. State List only from Orient Point, L. I., on corn; we add Southold, L. I., July 26, 1933 (Leonard) abundant on young corn; and Hammond, Sept. 11, 1933 (T. E. Petrie) on corn.

**A. rumicis** L. Since only *Arctium lappa* and *Chenopodium* sp. and buckwheat are specifically recorded in the N. Y. State List as food plants the following are added: *Viburnum opulus*, gladiolus, calendula, *Polyanthes tuberosa* and *Celastrus scandens* at Ithaca in 1932-1934; on thistle, Etna, Oct. 16, 1932 (Leonard & Crosby); on dahlias at Oswego, Sept. 18, 1934 (Chas. Palm); on *Rumex* sp., Babylon, L. I., May 5, 1934; and on tulips in greenhouse, Mar. 13, 1934 (F. S. Blanton).

**A. sanborni** Patch. Previously recorded only from Maspeth, L. I., on *Sambucus*. E. Williamson, Sept. 20, 1933, on celery (E. M. Patch det.); and Oct. 13, 1933, also on celery (A. N. Tissot det.).

**A. tulipæ** (Boyer) (= *gladioli* Felt). Recorded only from the type material from Berlin on gladiolus; it was collected by G. F. MacLeod Aug. 26, 1935, at Ithaca on Iris from Redlands, California, received Mar. 8, 1935.

**A. viburnicola** Gill. Previously recorded only from Maspeth, L. I. Ithaca, Oct. 17, 1932 (Leonard); and Sept. 18, 1934 (Leonard & Crosby) on *Viburnum opulus*. Freeville, Sept. 15, 1934 (Leonard & Crosby) on *V. dentatum* and *V. lentago*.

**Caviariella ægopodii** (Scop.). Listed as *C. pastinacæ* L. from Ithaca and from Maspeth, Long Island. Freeville, Oct. 16, 1932 (Leonard & Crosby) from *Salix* sp.; and East Aurora, Aug. 10, 1933 (Leonard & Crosby) host not recorded but probably *Cicuta* sp.

**Caviariella capræ** (Fab.). Poughkeepsie, Dec. 12, 1936 (S. C. Wilbur through C. R. Crosby), common on celery in storage. Previously recorded only from Maspeth, L. I., on cultivated parsnip (Olsen).

**Hyalopterus atriplicis** (L.) Olsen's record (as Aphis) from Maspeth, L. I., July 17, 1913, and Aug. 2, 1914, on *Chenopodium album* was omitted from the State List and we now also add East Aurora and Riverhead. This species is probably present wherever lamb's quarters (*Chenopodium album*) grows in the state.

**Rhopalosiphum rhois** (Mon.). Previously recorded only from Ithaca; we have taken it at Ithaca and Egleston's Glen, Sept., 1933, 1934, on *Rhus glabra* and Smokebush (*Cotinus cotinus*); also Babylon, L. I., July 12 and Aug. 15, 1934 (F. S. Blanton) on leaves of sumac.

**Calaphis betulæcolens** (Fitch.). The first definite record for Long Island is from Dix Hills, July 11, 1934 (F. S. Blanton) on *Betula nigra*.

**Melanocallis caryæfoliæ** (Davis). Previously listed only from Fitch's original record of his *Myzocallis fumipenellus* (Fitch). We now add Ithaca, Sept. 29, 1933 (Crosby) on hickory; and Egleston's Glen, Sept. 11, 1934 (Leonard & Crosby) on shag-bark hickory.

**Myzocallis walshii** (Mon.). Previously listed only from Geneva on *Quercus rubra*. Ithaca, Sept. 29, 1933 (Crosby) on *Quercus borealis*; and from Riverhead, L. I., Sept. 9, 1934 (Leonard & Crosby) on oak leaves.

**Tuberculatus punctatellus** (Fitch). Previously recorded (under *Myzocallis*) only from Fitch's original record. We now



add Ithaca, Sept. 30, 1933 (Crosby); and Sept. 22, 1934 (Leonard & Crosby) on leaves of *Quercus alba*.

**Macrosiphum chrysanthemi** (Oest.). Previously listed only from Sheridan (as *Tritogenaphis*). Ithaca, Sept. 14, 1934 (Leonard & Crosby) on *Eupatorium urticæfolium*; and from Ringwood, Tompkins Co., Sept. 10, 1934 (Crosby & Leonard) on *Bidens*.

**M. liriodendri** (Mon.). Definitely listed only from vicinity of New York City (as *Illinoia*), now also from Ithaca, Sept. 15, 1933 (Crosby); and Sept. 13, 1934 (Leonard & Crosby) on tulip tree.

**M. rosæ** (L.). Recorded in the New York List only from Maspeth, L. I., on rambler rose. We now add Ithaca, on sweet-briar rose and teasel and Ringwood on teasel, Sept., Oct., 1932-1934 (Leonard and Crosby) but the species is presumably widely distributed in the State.

**M. rudbeckiæ** (Fitch). Previously definitely recorded only from Long Island and the Hudson River Valley, we have made several collections from Ithaca and vicinity as well as on Long Island from goldenrod, golden glow and *Aster umbellata* (Leonard & or Crosby 1933 and 1934). A collection from *Pyrrhospappus carolinianus*, Babylon, L. I., July 12, 1934 (F. S. Blanton) is doubtfully labelled as *rudbeckiæ* by Tissot.

**M. sanborni** Gill. Previously recorded only from chrysanthemum at Ithaca. Babylon, L. I., Dec. 18, 1934 (F. S. Blanton) on greenhouse chrysanthemum; and from Sea Breeze, Monroe Co., Nov. 10, 1933 (J. M. VanDorn) also on chrysanthemum.

**Pemphigus populicaulis** Fitch. Reported in the New York List only from Ithaca, Albany and Mineola, we now add East Aurora, Aug. 10, 1933 (Leonard & Crosby) on *Populus* sp. Presumably widely distributed in the State.



A REVISION OF CONNECTANT FORMS BETWEEN  
CÆNOSIAN AND LIMNOPHORINE GENERA  
OCCURRING IN NORTH AMERICA  
(DIPTERA, MUSCIDÆ)

BY H. C. HUCKETT

RIVERHEAD, N. Y.

The present paper deals with those few genera that seemingly form a buffer group between the more typical cænosian and limnophorine segregates as they are represented in North America. Such a concept includes the genera *Atherigona* Rondani, *Limnospila* Schnabl, *Pseudocœnosia* Strobl, *Phyllogaster* Stein, and *Macrororchis* Rondani. Karl (7)\* has assembled this group under the tribe Chelisiini (subfamily Cœnosiinæ), but that tribal name for this group is, in my opinion, invalidated by the fact that the genus *Chelisia* does not belong to this subfamily.

The above genera may be linked together by the possession of the following characters: The presence of one pair of reclinate parafrontal bristles adjacent the ocellar callosity; the arrangement of the sterno-pleural bristles in the form of an equilateral triangle; the presence of two pairs of presutural dorsocentral bristles; the vein *Cu.*<sub>2</sub> + 1st *A.* is traceable to beyond half-way to margin of wing; the absence of cruciate bristles on frontal vitta; the well marked development of the lower calyptal scale beyond the confines of the upper.

The European genus *Dexiopsis* Pokorny (23), although belonging to this group, has been incorrectly recorded by Stein (41), Aldrich (1), Williston (44), and others, as occurring in North America. Stein's inclusion of the genus was founded on his description of *Dexiopsis basalis* (33), a species which Malloch (12) correctly recognized as not being congeneric, and which he later made the type of the new genus *Neodexiopsis* (13). Aldrich (1) included North American records of *Anthomyza lacteipennis* Zetterstedt under *Dexiopsis*, but Johannsen (6) has pointed out that this species is none other than *Lispocephala*

\* Numbers in brackets refer to literature cited.

*erythroceræ* (Robineau-Desvoidy), and should not be confused with *Aricia lacteipennis* Zetterstedt, a true *Dexiopsis*.

#### KEY TO GENERA

1. Fore femur with a complete series of posteroventral bristles, from base to apex; eyes hemispherical in outline, narrower ventrad than at middle; mesonotum with at least one pair of presutural dorsocentral bristles as well developed as the posterior notopleural bristle; costal cell normal in size, not enlarged by the convexity of costa, subcosta uniting with costa at a point proximad of that opposite *r-m* cross vein ..... 2
- Fore femur with only one or two bristles on posteroventral surface, distad; eyes oblong in outline, width at lower third as great as that at middle; mesonotum with presutural dorsocentral bristles weakly developed, shorter than posterior notopleural bristle; costal cell abnormal in size, the costa bounding the cell slightly convex, and subcosta uniting with costa at a point opposite *r-m* cross vein ..... *Atherigona* Rondani
2. Arista with a longish thickening throughout proximal third; second antennal segment markedly depressed proximad on dorsum adjacent the stigma, as if the segment were pinched basad ..... *Phyllogaster* Stein
- Arista thickened only at base; second antennal segment normal in appearance, with no depressed area proximad ..... 3
3. Ocellar triangle short, not extending cephalad to base of antennæ, and not densely whitish pruinose, when viewed from in front; distance between bases of inner pair of vertical bristles much shorter than the length of either bristle; hind femur with well developed bristles on proximal half of anteroventral surface; hypopygium in male conspicuous; large species, 5 mm. + ..... 4
- Ocellar triangle extending to base of antennæ, with dense whitish pruinescence; distance between bases of inner pair of vertical bristles about as great as length of either bristle; hind femur with no well developed bristles on proximal half of anteroventral surface; small species, 4 mm. .... *Limnospila* Schnabl
4. Frontal vitta at middle scarcely wider than twice breadth of either parafrontal; caudal pair of ocellar bristles weakly developed, not longer than presutural acrostical bristles, directed forward; lower stigmatal bristle directed upward; prosternum shining, polished. .... *Pseudocoenosia* Strobl
- Frontal vitta at middle much wider than twice breadth of either parafrontal; caudal pair of ocellar bristles well developed, longer than presutural acrostical bristles, directed outwards; lower stigmatal bristle directed downward; prosternum grayish pruinose. .... *Macrorchis* Rondani

#### Genus *Atherigona* Rondani

*Atherigona* Rondani, Dipt. Ital. Prodr., 1856 I p. 97. . . .  
 Schiner, Faun. Austr., 1862 I p. 669. . . . Rondani, Atti



Soc. Ital. Scienz. Natur., 1866 IX p. 76. . . . Rondani, Dipt. Ital., Prodr., 1877 VI (5) pp. 15, 250. . . . Meade, Ann. Mag. Nat. Hist., 1883 XX pp. 59, 107. . . . Meade, Deser. List Brit. Anth., 1897 II p. 76. . . . Pandellé, Rev. ent. France, 1899 XVIII p. 161. . . . Stein, Termesz. Fürzetek., 1900 XXIII pp. 154-159. . . . Schnabl, Wien. Ent. Zeitg., 1902 XXI (8-9) pp. 199-202. . . . Stein, Mittheil. Zool. Mus. Berlin, 1903 II p. 110. . . . Stein, Katal. Paläark. Dipt., 1907 III p. 676. . . . Schnabl and Dzeidzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 1911 XCV (2) pp. 181-183. . . . Stein, Ann. Mus. Nat. Hungar., 1913, XI pp. 529-541. . . . Stein, Arch. f. Naturgesch., 1914 (1913) A (8) p. 11. . . . Stein, Arch. f. Naturgesch., 1916 (1915) A (10) pp. 117, 220. . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) p. 145. . . . Aldrich, Ins. Inse. Menstr., 1921 IX (4-6) pp. 93-98. . . . Malloch, Ent. News, 1921 XXXII p. 106. . . . Malloch, Ann. Mag. Nat. Hist., 1922 ser. 9 X p. 575. . . . Séguy, Faune de France, 1923 (6) p. 249. . . . Malloch, Ann. Mag. Nat. Hist., 1924 ser. 9 XIII pp. 410-413; XIV p. 518. . . . Malloch, Proc. Linn. Soc. N. S. Wales, 1924 XLIX Pt. 2 p. 145; 1925 L Pt. 2 p. 44. . . . Malloch, Mem. Dept. Agr. Ind., Ent. Series, 1925 VIII No. 11 pp. 111-122. . . . Ramachandra Rao, Mem. Dept. Agr. Ind. Ent. Series, 1925 VIII No. 11 pp. 123-125. . . . Malloch, Ent. Mittheil., 1928 XVII (4) pp. 297-303; (5) pp. 310-313. . . . Karl, Tierwelt Deutschlands, 1928 XIII (3) p. 209. . . . Malloch, Insects of Samoa, 1929 Part VI Fasc. 3 pp. 157-159. . . . Curran, Fam. Gen. N. A. Dipt., 1934 p. 396.

*Acritochæta* Grimshaw, Fauna Hawaiiensis, 1902 II p. 41. . . . Stein, Arch. f. Naturgesch., 1911 A (1) p. 145.

#### Genotype *Cænosia varia* Meigen

The genus *Atherigona* was erected by Rondani (26) in 1856, with *Cænosia varia* Meigen as type. In 1862 Schiner (28), in redescribing the genus, cited *varia* as a synonym of *Musca quadripunctata* Rossi. The genus has been accepted generally by authors as valid, although no such unanimity of opinion has

been expressed regarding its generic relationships. This problem has no doubt been rendered difficult owing to the aberrant appearance of the species. Schnabl (30) in 1902, and again (31) in 1911, after listing the motley collection of characters belonging to the genus, concluded that it might be regarded as an intermediate form between the muscoid group of genera and the tachinid genus *Siphona* Meigen. Stein (35) (38) (39) (41), in most of his more important contributions placed the genus near the limnophorine genera as opposed to those allied to *Cænosiæ*, c.f., *Macrorchis*, *Dexiopsis*. In this he was followed by Séguy (32). Malloch (14) (15) at first placed the genus among others belonging to the subfamily *Cænosiinæ*, but later (18) (19) came to regard its position as more closely in keeping with the *Phaoniinæ* (11). Recently Malloch (21) has restored the genus to the *Cænosiinæ*, basing his action on the fact that the species possess only one pair of reclinate parafrontal bristles at vertex of head. Karl (7) in recording the German fauna included the genus among eight comprising his tribe *Chelisiini* of the subfamily *Cænosiinæ*, a group to which I believe it most naturally belongs though not under that name.

In 1902 Grimshaw (5) described the genus *Acritochaeta*, with sole species *A. pulvinata* new. This group represents those species of the genus *Atherigona* in which many of the males have a shallow dorsal impression along the distal region of fore femur, and in which the male genitalia lack the trifoliate process borne at tip of a slender stalk, characters which serve to distinguish the segregate from that of *varia* and associated species. Stein (36) at first regarded the group as entitled to generic rank, but later (37) reduced it to subgenus. Malloch (17), on account of the secondary sexual nature of the characters, refrained from recognising the group. Ramachandra Rao (24) in studying the habits of some of the Indian species of *Atherigona* found that they could be satisfactorily placed into two distinct groups according to their larval habits, supporting thereby the proposed division of the genus into two groups on the basis of the presence or absence of certain male characters in the adult.

I have used the genus *Atherigona* in its traditional sense, believing that, in the light of present knowledge, the segregate *Acri-*

tochaeta may be accepted as of subgeneric significance. The species described by Grimshaw as *Acritochæta pulvinata* is, in my opinion, none other than *Atherigona orientalis* Schiner, which species had been previously recorded by Malloch (14) as occurring in Florida under the name *A. varia* Meigen.

Diagnostic characters: Costal cell enlarged by the slight convexity of costa and by the termination of subcosta in costa at a point nearly opposite the *r-m* cross vein; presutural dorsocentral bristles inconspicuous, shorter than posterior notopleural bristle; dorsal bristle of mesopleural series setulose in character; eyes oblong in outline, width on lower third equal to that at middle; fore femur with posteroventral bristles restricted to distal third of surface.

***Atherigona (Acritochæta) orientalis* Schiner**

?*Atomogaster triseriata* Walker, Proc. Linn. Soc. London, 1861 VI p. 11.

*Atherigona orientalis* Schiner, Reise oesterreich. Fregatte Novara, Dipt., 1868 p. 295. . . . Stein, Annal. Mus. Civico Storia Natural. Genova, 1900 ser. 2 XX (40) p. 22.

*Cænoscia excisa* Thomson, Kongl. Svensk. Fregatten Eugenies Resa, Dipt., 1868 p. 560.

*Atherigona trilineata* Stein, Term. Füz., 1900 XXIII p. 157. . . . Stein, Tijdschr. v. Ent., 1909 LII p. 253.

*Acritochæta pulvinata* Grimshaw, Fauna Hawaiiensis, 1902 II p. 41.

*Atherigona magnipalpis* Stein, Berl. Ent. Zeitschr., 1906 LI p. 66.

*Atherigona (Acritochæta) excisa* Stein, Wien. Ent. Zeitg., 1910 XXIX (2-3) p. 76. . . . Stein, Ann. Mus. Nat. Hungar., 1918 XVI pp. 158, 177.

*Acritochæta trilineata* Stein, Arch. f. Naturgesch., 1911 A (1) p. 145.

*Acritochæta excisa* Stein, Suppl. Entomol., 1915 No. 4 p. 42.

*Atherigona excisa* Stein, Arch. f. Naturgesch., 1919 (1917) A (1) p. 145. . . . Malloch, Ann. Mag. Nat. Hist., 1923 ser. 9 XII p. 185; 1924 ser. 9 XIII p. 413. . . . Malloch, Mem. Dept. Agr. Ind., Ent. Series, 1925 VIII (11) p. 115. . . . Ramachandra Rao, Mem. Dept. Agr. Ind., Ent. Series, 1925

VIII (11) p. 124. . . . Illingworth, Proc. Haw. Ent. Soc., 1927 VI p. 395.

*Atherigona pulvinata* Aldrich, Ins. Inscit. Menstr., 1921 IX (4-6) p. 96.

*Atherigona varia* Malloch not Meigen, Ent. News, 1921 XXXII p. 107.

In naming the species *orientalis* Schiner and not *excisa* Thomson I do so without having succeeded in obtaining authentic information relative to the dates of issue of the two works concerned. Verrall in reviewing Thomson's work in the Zoological Record for 1869 stated that he feared that many of the species were synonyms owing to the appearance of Schiner's work in the same year. Brauer, according to Osten Sacken (22), contended that Thomson's volume was not actually issued until 1869, a contention, it is thought, which might have been motivated by the desire of securing the priority of Schiner's names. Stein (41) in his catalogue of the anthomyian genera of the world gave *excisa* priority over *orientalis*, as have most authors. I have accepted Verrall's statement as indicative of the fact that Schiner's work was the first to be issued, hence the prior claims of *Atherigona orientalis* as the name for the species. I have cited the synonymy revealed by Stein (40) (41) and Malloch (16).

The species is the only one of the genus recorded as occurring in North America, being confined to those parts of the southern States where tropical and subtropical conditions exist. In fact although associated with other species of the genus in other parts of the world, it is so far the only species recorded from neotropical regions. Its interspecific relationships have been fully dealt with by Malloch (17) (20). Florida, 2 ♂, 2 ♀, Dunedin, Jan. 30, 1932 (A. L. Melander).

#### Genus *Phyllogaster* Stein

*Tetrachæta* Stein not Ehrenberg, Berl. Ent. Zeitschr., 1898 (1897) XLII (3-4) p. 254. . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 559. . . . Williston, Manual N. A. Dipt., 1908 3rd ed. p. 336.

*Phyllogaster* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII



(3-4) p. 256. . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 559. . . . Williston, Manual N. A. Dipt., 1908 3rd ed. p. 336. . . . Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII (1719) p. 590. . . . Malloch, Canad. Ent., 1917 XLIX p. 227. . . . Malloch, Bull. Brooklyn Ent. Soc., 1917 XII (2) p. 36. . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) pp. 95, 141. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) pp. 58, 59. . . . Malloch, Canad. Ent., 1921 LIII p. 11. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835. . . . Curran, Fam. Gen. N. A. Dipt., 1934 p. 399.

Tetramerinx Berg, Comm. Mus. Nac. Buenos Aires, 1898 I p. 17. . . . Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII (1719) p. 613. . . . Stein, Arch. f. Naturgesch., 1911 A (1) p. 144. . . . Bezzi, Wien, Ent. Zeitg., 1907 XXVI (2) p. 54. . . . Bezzi, Zeitschr. f. Hymen. u. Dipt., 1908 VI p. 50. . . . Malloch, Canad. Ent., 1917 XLIX pp. 225, 226. . . . Malloch, Bull. Brooklyn Ent. Soc., 1917 (XII) (2) p. 36. Malloch, Trans. Amer. Ent. Soc., 1918 No. 782 p. 273. . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) pp. 95, 141. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) pp. 59, 60. . . . Malloch, Canad. Ent., 1921 LIII p. 11. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 834.

Parasteinia Cockerell, Canad. Ent., 1905 XXXVII p. 361.

Genotype *Phyllogaster cordyluroides* Stein

The genus *Phyllogaster* was described by Stein (33) in 1898 for the reception of one species, *P. cordyluroides* new. In 1910 Coquillett (4) designated Stein's species as the genotype. Four additional species have been included in the genus, all from North America.

The allied genus *Tetrachæta* was erected by Stein at the same time as *Phyllogaster* for the reception of the single species *T. unica* new. Its description has precedence over that of *Phyllogaster*, but because the name *Tetrachæta* has been found to be a homonym it thereby has forfeited its claims to priority, should such an occasion arise. In the same year Berg (2) called atten-

tion to the preoccupation of the name by Ehrenberg in 1844, and proposed the new name *Tetramerinx* for the genus. In 1905 Cockerell (3) inadvertently proposed another name, *Parasteinia*, citing the same reason as proposed by Berg for the change.

In 1910 Coquillett (4) designated *T. unica* as the genotype of *Tetramerinx*, and henceforth the treatment of the group has closely paralleled that of *Phyllogaster*. Three species have been assigned to the genus, all of which have been found to occur in North America.

The habitus of the species of the two genera *Phyllogaster* and *Tetramerinx* is apparently similar, the adults having been found in the vicinity of marshy ground and sand dunes along the coast line from Maine to Texas, at various places along the Pacific coast from Washington to lower California, and also in the vicinity of the beaches of some of the Great Lakes. I have made a careful study of the characters used in separating the genera, and find that few, if any, are of real worth. In fact there are present other characters common to the two groups which appear so strong that there seems to me little reason for maintaining the two segregates apart. These common distinctions are to be found in the peculiar dorsal depression at base of second antennal segment, as if the segment here had been flattened, in the lengthened thickening of the arista on proximal half, and in the relatively robust development of the caudal pair of ocellar bristles, which are directed outwards.

#### KEY TO SPECIES

1. Thorax with four pairs of postsutural dorsocentral bristles .....2
- Thorax with three pairs of postsutural dorsocentral bristles .....4
2. Hind tibia with apical posteroventral bristle stoutly developed; hind femur with well developed bristles continued to near base of anteroventral surface; cheeks as high as half height of eye; fore tibia with a mid anterodorsal bristle; female with no recurved spines on subanal plate of ovipositor .....*inermis* Stein
- Hind tibia with apical posteroventral bristle setulose, weakly developed; hind femur with well developed bristles restricted to distal half of anteroventral surface; cheeks not as high as half height of eye; fore tibia with no mid anterodorsal bristle; female with recurved spines on subanal plate of ovipositor .....3
3. Tibiæ blackish; abdomen with at most a dorsocentral streak, otherwise unmarked; mid tibia with an anterodorsal bristle; male with processes

- of fifth sternum sharply tapered apicad, polished at apex and along outer border ..... *unicus* Stein
- . Tibiæ reddish; abdomen with a dorsocentral vitta and a pair of spots on terga 3 and 4 respectively; mid tibia with no anterodorsal bristle; male with processes broadly rounded apicad, not polished ..... *rufitibia* Stein
4. Hind tibia with apical posteroventral bristle stoutly developed ..... 5
- . Hind tibia with apical posteroventral bristle weakly developed, setulose ..... 8
5. Fore tibia with a mid posteroventral bristle; mid tibia with a mid anterodorsal bristle; hind tibia with 3 bristles at apex of dorsum. .... *robustus* Johnson
- . Fore tibia with no mid posteroventral bristle; mid tibia with no mid anterodorsal bristle; hind tibia with 2 bristles at apex of dorsum. .... 6
6. Arista with longest hairs as long as setulæ on first antennal segment; hind tibia with distal posterodorsal bristle much longer ( $\times 1.5$ ) than proximal posterodorsal bristle ..... *longispinus* Malloch
- . Arista with longest hairs not as long as setulæ on first antennal segment; hind tibia with distal posterodorsal bristle not longer than proximal posterodorsal bristle ..... 7
7. Prebasal scutellar bristles shorter than caudal pair of dorsocentral bristles; pulvilli small, wider than long; female with recurved spines on ovipositor as stoutly developed as the abdominal macrochaetæ. .... *mallitosus* new sp.
- . Prebasal scutellar bristles as long as caudal pair of dorsocentral bristles; pulvilli elongate, well developed, longer than wide; female with recurved spines on ovipositor weaker in development than abdominal macrochaetæ ..... *cordyluroides* Stein
8. Abdomen with dorsocentral vitta and paired spots on terga 3 and 4 respectively; hind tibia with 2 posterodorsal bristles; arista thickened on proximal half; proximal sector of  $R_{4+5}$  bare ..... *parvimaculatus* Stein
- . Abdomen with no markings; hind tibia with 1 posterodorsal bristle; arista thickened on proximal two-fifths; proximal sector of  $R_{4+5}$  frequently with setulæ or traces of such ..... *littoralis* Malloch

### *Phyllogaster inermis* Stein

*Phyllogaster inermis* Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 58.

The species has four pairs of postsutural dorsocentral bristles, as in the case of *unicus* and *rufitibia*, but from these species it may be distinguished by the possession of a stoutly developed apical posteroventral bristle on hind tibia, and by the presence of well developed bristles on proximal as well as on distal half of anteroventral surface of hind femur. The female evidently differs from all others known to me in the genus in lacking the recurrent spines on subanal plate of ovipositor.

California, 1 ♀, Stanford Univ., Oct. 190—. (U. S. N. M.)  
 Washington, 1 ♂, Dewatto, Aug. 15 1910; 1 ♀, Friday Harbor,  
 July 7 1905 (Z. M. U. B.).

**Phyllogaster unicus** (Stein)

*Tetrachæta unica* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII  
 (3-4) p. 254.

*Tetramerinx unica* Aldrich, Misc. Smithsn. Inst., 1905 XLVI No.  
 1444 p. 559. . . . Smith, Ann. Rept. N. J. State Mus., 1909,  
 1910 p. 792. . . . Malloch, Canad. Ent. 1917 XLIX p. 226.  
 . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) p. 141.  
 . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 60.  
 . . . Malloch, Canad. Ent., 1921 LIII p. 11. . . . Johnson,  
 Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 230. . . .  
 Hallock, Circ. 103 N. J. Dept. Agr. 1926 p. 17. . . . John-  
 son, Insect Fauna, Biol. Surv. Mt. Desert Region, 1927 p.  
 209. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp.  
 Station, 1928 (1926) p. 834.

The species is associated with *rufitibia* and *inermis* in that the thorax of all three species has four pairs of postsutural dorso-central bristles, but from the former species *unicus* may be distinguished by the blackish tibiae, the possession of an anterodorsal bristle on mid tibia, and by the lack of paired marks on abdomen; from *inermis*, by the lack of a stoutly developed apical posteroventral bristle on hind tibia, by the absence of bristles on proximal half of anteroventral surface of hind femur, and in the female by the presence of four recurved spines on subanal plate of ovipositor.

Alberta, 1 ♂, Lethbridge, Sept. 4 1926 (H. L. Seamans) (C. N. C.).

British Columbia, 1 ♀, Kalso, July 16. (U. S. N. M.).

California, 1 ♀, Fresno, Oct. 29 1922. (H. C. H.).

Colorado, 1 ♀, Grand Jet, June 14 1927 (U. S. N. M.).

Idaho, 2 ♂, Emmett, June 23, 1926, 2373 ft.; 1 ♀, Challis, July 7  
 1926, 5280 ft.; 1 ♀, Homedale, June 18 1926, 2238 ft.; 1 ♀,  
 Mt. Home, June 15 1926, 3138 ft. (Haegele) (Univ. Idaho).

Maryland, 3 ♂, 3 ♀, Chesapeake Beach, Aug. 19, 1919; 2 ♂, 4 ♀,  
 May 1930; 10 ♂, 8 ♀, June 30 1926 (J. M. Aldrich) (U. S.  
 N. M.).



Massachusetts, 1 ♀, Woods Hole, (U. S. N. M.); 3 ♀, Woods Hole, Aug. 2 1900 (Z. M. U. B.).

New Brunswick, 1 ♀, Shippigan, July 14 1931 (U. S. N. M.).

New Jersey, 2 ♀, Ocean City, May 7; 1 ♀, Sea Isle City (U. S. N. M.).

New York, 1 ♂, Montauk Point, Long Island, Sept. 4 1927; 2 ♀, Babylon, Long Island, July 26 1933; 1 ♀, June 20, 1932; 1 ♀, July 29 1933 (F. S. Blanton).

Nevada, 5 ♂, 10 ♀, Wells, June 20 1927 (J. M. Aldrich) (U. S. N. M.).

Nova Scotia, 1 ♂, Truro, July 4 1913 (R. Matheson).

Rhode Island, 3 ♀, Newport, June 9, 1914.

Virginia, 2 ♂, Va. Beach, June 22 1933 (U. S. N. M.).

Washington, 1 ♂, Ringold, July 4 1919; 1 ♀, Lind, June 16 1919; 1 ♀, Lake Paha, July 20 1920 (R. C. Shannon).

#### *Phyllogaster rufitibia* (Stein)

*Tetramerinx rufitibia* Stein, Arch. f. Naturgesch., 1911 A (1) p. 144. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 59.

*Tetramerinx californiensis* Malloch, Trans. Amer. Ent. Soc., 1918 No. 782 XLIV p. 274. . . . Malloch, Canad. Ent., 1921 LIII p. 11.

The species has the tibiæ reddish as in *littoralis* and *parvumaculatus*, but from these species it may be distinguished by the presence of four pairs of postsutural dorsocentral bristles. The abdomen has paired markings, as in *robustus* and *cordyluroides*, but the tarsi do not possess the robust longish pulvilli that is characteristic of these two species.

California, 1 ♂, 1 ♀, San Francisco dunes, Nov. 11 1907 (J. C. Bradley) (Z. M. U. B.); 1 ♀, Ingleside, Aug. 26 1908 (J. C. Bradley).

#### *Phyllogaster robustus* Johnson

*Phyllogaster robustus* Johnson, Canad. Ent., 1917 XLIX p. 148. . . . Malloch, Canad. Ent., 1921 LIII p. 11. . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 230. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835.

*Phyllogaster maximus* Stein, Arch. f. Naturgesch., 1920 (1918)  
A (9) p. 59.

The species may be readily distinguished from allied forms by the presence of a well developed bristle at middle of posteroventral surface of fore tibia, and near middle of anterodorsal surface of mid tibia. In addition, there are invariably three well developed apical bristles on dorsum of hind tibia. In the male the basal sclerite of hypopygium exhibits a peculiar puckering of the chitin, such as is also present in specimens of *cordyluroides* and *mallitosus*.

Florida, 1 ♀, Biscayne Bay (Slosson) (U. S. N. M.).

Massachusetts, 1 ♀, Chatham, June 30 1904 (paratype); 1 ♀, Woods Hole, Aug. 2 1900; 1 ♂, Aug. 9 1900; 2 ♂ Eastham, May 30 1922 (U. S. N. M.); 1 ♂, 1 ♀, Edgartown, June 27 1912; 1 ♂, 1 ♀, Gloucester, June 20 1924 (H. C. H.).

New York, 1 ♀, Cold Spring Harbor, Long Island, July (U. S. N. M.).

Rhode Island, 1 ♂, Buttonwoods, June 17 1921 (paratype) (U. S. N. M.).

#### *Phyllogaster longispinus* Malloch

*Phyllogaster longispinus* Malloch, Proc. Cal. Acad. Sci., 1923 ser. 4 XII (21) p. 426.

I have included this species in the present study despite the fact that so far it has only been recorded from Gonzales Bay in Lower California. From what we know of the wide distribution of many species belonging to this genus it does not seem improbable that this species may be found in Southern California at least.

The species most closely resembles *robustus*, from which it may be distinguished by the lack of a bristle at middle of posteroventral surface of fore tibia and of anterodorsal surface of mid tibia, and by the presence of only two apical bristles on dorsum of hind tibia instead of three, as is invariably present in *robustus*. Also in the male the copulatory appendages are compact and not conspicuous as in *robustus* and *cordyluroides*. The distal bristle of anterodorsal and posterodorsal series and apical mid dorsal bristle of hind tibia are each longer than the length of hind metatarsus.

I have had the privilege of examining the female paratype in the collection of the United States National Museum.

**Phyllogaster mallitosus** new species

Male and female: Similar to *cordyluroides*, dove-gray in color, with no abdominal or thoracic markings except trace of a dorsocentral streak on abdomen. Vestiture sparse. All femora broadly yellowish at apex, all tibiae and tarsi yellowish, with trace of infuscation.

Male with prebasal pair of scutellar bristles shorter than caudal pair of dorsocentral bristles. Abdomen with bristles short and weakly developed, not as long as posterior notopleural bristle. Fore femur with posteroventral bristle fine and weakly developed except for one or two apicad, weaker than the bristles of posterodorsal series: fore tibia with no mid-posteroventral bristle, with apical posterodorsal bristle shorter than diameter of tibia where situated: mid femur with posteroventral bristles setulose: mid-tibia with 2 short posterodorsal bristles: hind femur with 1 or 2 bristles on distal third of anteroventral surface, with 2 or 3 setulose bristles on proximal third: hind tibia with 1 anteroventral, 2 anterodorsal, 1 or 2 posterodorsal bristles, and with a well developed apical posteroventral bristle. Tarsi with claws and pulvilli inconspicuously developed. Length, 3.5-5 mm.

Female similar to male in chaetotaxy except that the bristles are stronger and slightly longer: ovipositor with a pair of stoutly developed recurved spines at apex of subanal plate. Length, 4-5.5 mm.

Type and allotype, Chesapeake Beach, Maryland, Aug. 19 1919 (J. M. Aldrich) (U. S. N. M.).

The species was included under the name *P. cordyluroides* in the United States National Museum collection, of which it appears as a pale unmarked form. There are however, in my opinion, certain structural differences present which have led me to believe that the specimens represent a distinct species. The prebasal pair of scutellar bristles is shorter than the caudal pair of dorsocentral bristles on the mesonotum, and the apical posterodorsal bristle on fore tibia and all pulvilli are short and weak in development. In the male the gonostyli (inferior forceps) lack setae on the outer surface, and in the female the pair of recurved spines on subanal plate of ovipositor is strongly developed. In *cordyluroides* the prebasal pair of scutellar bristles is as long as the caudal pair of dorsocentral bristles, and the apical posterodorsal bristle on fore tibia and all pulvilli are well developed. In the male the gonostyli are clothed with setae

on outer surface, and in the female the recurved spines on subanal plate of ovipositor are relatively small in development.

Florida, 1 ♂, 1 ♀, St. Augustine (U. S. N. M.).

Maryland, 4 ♂, 4 ♀, Chesapeake Beach, July 19 1919 (U. S. N. M.).

Virginia, 1 ♂, 1 ♀, Va. Beach, 1933 (U. S. N. M.).

### **Phyllogaster cordyluroides** Stein

*Phyllogaster cordyluroides* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII (3-4) p. 256. . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 559. . . . Johnson, Psyche, 1909 XVI (1) p. 5-12. . . . Smith, Ann. Rept. N. J. State Museum, 1909, 1910 p. 797. . . . Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII No. 1719 p. 590. . . . Johnson, Bull. Amer. Mus. Nat. Hist., 1913 XXXII (3) p. 78. . . . Malloch, Canad. Ent., 1917 XLIX p. 227. . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) p. 141. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 59. . . . Malloch, Canad. Ent., 1921 LIII p. 12. . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist. No. VII 1925 p. 230. . . . Johnson, Insect Fauna, Biol. Surv., Mt. Desert Region, 1927 p. 209. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835. . . . Ogilvie, Insects of Bermuda, 1928 p. 43.

There is only one species with which *cordyluroides* may be confused, namely *mallitosus*. I have seen pale specimens of *cordyluroides* from Florida and Texas, as noted by Malloch (10a), which do not display clearly the markings of the abdomen, but such specimens have the prebasal pair of scutellar bristles as long as the caudal pair of dorsocentral bristles, the apical postero-dorsal bristle of fore tibia and all pulvilli well developed, and, in the female the recurved spines on subanal plate of ovipositor are proportionately small in size. Most of the specimens I have seen bear at least traces of tergal markings on abdomen. It is interesting to note that this is the only species belonging to the genus that has been recorded as occurring elsewhere than on the American continent, namely in Bermuda.

Florida, 2 ♀, St. Augustine (Coq.) (U. S. N. M.).



- Maine, 1 ♀, Narrows, Mt. Desert, July 27 1919.  
Maryland, 1 ♀, Chesapeake Beach, June 30 (U. S. N. M.).  
Massachusetts, 1 ♂, Woods Hole, July 2 1900.  
Missouri, 1 ♀, Pass Christian, June 7 1917.  
New Jersey, 1 ♂, 1 ♀, Sea Isle City, July 22 1894.  
New York, 1 ♂, Sea Cliff, Long Island, Aug.-Sept. 5 1910 (N. Banks).  
Texas, 5 ♂, 7 ♀, Galveston, June 10 1917 (J. M. Aldrich) (U. S. N. M.).

**Phyllogaster parvimaculatus** (Stein)

*Tetramerinx parvimaculata* Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 60.

There is little that need be added to Stein's description of the species to ensure its recognition. I have indicated in the key that the species structurally approaches that of *littoralis*, differing essentially in having a second posterodorsal bristle on hind tibia. In addition the species possesses restricted markings on abdominal terga 3 and 4, which in *littoralis* are lacking.

Texas, 3 ♂, 1 ♀, Galveston, June 1900 (cotypes) (U. S. N. M. and Z. M. U. B.).

**Phyllogaster littoralis** Malloch

*Phyllogaster littoralis* Malloch, Canad. Ent., 1917 XLIX pp. 227, 228. . . . Malloch, Ent. News, 1918 XXIX p. 32. . . . Malloch, Canad. Ent., 1921 LIII p. 12. . . . Frison, Bull. Ill. Nat. Hist. Surv., 1927 XVI (3) p. 207. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835.

The species may be readily recognized by its yellowish tibiæ, the presence of three pairs of postsutural dorsocentral bristles, and by the absence of a well developed apical posteroventral bristle on hind tibia. In addition the abdomen and thorax are uniformly pale gray, densely dusted, and have no marks; the hind tibia has only I posterodorsal bristle, situated proximad, and the tarsal claws are proportionately small in size. Most of the specimens examined possess one or more setulæ on the under surface of the proximal sector of vein *R*.<sub>4+5</sub>.

Alberta, 1 ♀, Miberrie, Sept. 8 1924 (H. L. Seamans).

Colorado, 1 ♀, Ft. Collins, Aug. 19 1906 (U. S. N. M.).

- Illinois, 2 ♂, 3 ♀, Waukegan, Aug. 24 1917.  
 Indiana, 3 ♂, 5 ♀, Michigan Cy., Sept. 5 1927 (J. M. Aldrich);  
 2 ♀, June 29 1915 (U. S. N. M.).  
 New Jersey, 1 ♀, Sea Isle City, March 22 1894 (U. S. N. M.).  
 New York, 3 ♂, 1 ♀, Oswego, July 2 1896; 1 ♀, Ontario Beach,  
 N. Fairhaven, July 3 1922.  
 Pennsylvania, 1 ♂, 9 ♀, Presque Isle, Aug. 5 1924 (H. Kahl).  
 Quebec, 1 ♂, Kazubazua, Aug. 17 1927 (G. S. Walley).  
 South Dakota, 2 ♂, 1 ♀, Mobridge, Aug. 13 1924: 1 ♀, Hot  
 Springs, July 9 1924: 1 ♂, Springfield, June 25 1924.  
 Utah, 1 ♀, Lewiston, July 2 1927 (G. F. Knowlton) (U. S. N. M.).  
 Wyoming, 1 ♀, Old Faithful, Yellowstone Park, Aug. 12 1927  
 (J. M. Aldrich) (U. S. N. M.).

### Genus *Limnospila* Schnabl

- Limnospila* Schnabl, Wien. Ent. Zeitg., 1902 XXI p. 111. . . .  
 Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p.  
 562. . . . Williston, Manual N. A. Dipt., 1908 3rd ed. p. 336.  
 . . . Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Akad.  
 Naturforsch., 1911 XCV Nr. 2 pp. 141, 142. . . . Stein,  
 Arch. f. Naturgesch., 1916 (1915) A (10) pp. 112, 220. . . .  
 Ringdahl, Ent. Tidskr., 1918 XXXIX p. 160. . . . Stein,  
 Arch. f. Naturgesch., 1919 (1917) A (1) p. 95. . . . Séguy,  
 Faune de France, 1923 (6) p. 194. . . . Karl, Tierwelt  
 Deutschlands, 1928 XIII (3) p. 207. . . . Hockett, Mem.  
 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835.  
 . . . Ringdahl, Ent. Tidskr., 1929 L p. 13. . . . Curran,  
 Fam. Gen. N. A. Dipt., 1934 p. 396.  
*Coenosia* Stein, Katal. Paläark. Dipt., 1907 III p. 735. . . .  
 Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII No. 1719  
 p. 526.

Genotype *Aricia albifrons* Zetterstedt.

The genus *Limnospila* was erected by Schnabl (29) in 1902 for the reception of *Aricia albifrons* Zetterstedt. Heretofore the species *albifrons* has been commonly referred to *Cœnosia* Meigen owing to the widely separated eyes in both sexes and the arrangement of the sternopleural bristles to form an equilateral triangle. Strobl (43) in 1893 included the species in his segregate *Pseudo-*

limnophora as *obscuripes* Rondani, a synonym of *albifrons*. Later in the same year Pokorny (23) arbitrarily changed the name of such a group to *Stroblia*, placing therein most of the species listed under *Pseudolimnophora*, including *albifrons*. Schnabl considered *albifrons* as generically distinct from *Musca triangula* Fallén, the type of *Stroblia* and *Pseudolimnophora*, on account of the triangular position of the sternopleural bristles, and hence he proceeded, as above mentioned, to erect the genus *Limnospila*. Since this time the group has remained monobasic. From all limnophorine genera *Limnospila* differs essentially in possessing only one pair of reclinate parafrontal bristles on vertex of head, instead of two such pairs. Despite the distinctive appearance of *albifrons* itself I have been unable to recognise any good tangible characters on which to base the genus. In both sexes the frontal vitta is divided by a densely dusted whitish ocellar triangle, which extends to base to antennæ. In the male the whole frons is more or less silvery pruinose. The inner pair of vertical bristles is widely separated, the distance being nearly equal to length of either bristle. The caudal pair of ocellar bristles is weakly developed, the bristles being no longer than the presutural acrostical bristles. The abdominal terga bear subtriangular marks.

***Limnospila albifrons* (Zetterstedt)**

*Aricia albifrons* Zetterstedt, Dipt. Scand., 1849 VIII p. 3301.

*Coenosia obscuripes* Rondani, Della Soc. Ital. Scienz. Natur., 1866 IX p. 203. . . . Rondani, Dipt. Ital., Prodr., 1877 VI (5) p. 267. . . . Strobl, Verh. zool.-bot. Gesellsch. Wien, 1893 XLIII p. 273. . . . Pandellé, Rev. ent. France, 1899 XVIII p. 154.

*Pseudolimnophora obscuripes* Strobl, Verh. zool.-bot. Gesellsch. Wien, 1893 XLIII p. 273.

*Stroblia albifrons* Pokorny, Verh. zool.-bot. Gesellsch. Wien, 1893 XLIII pp. 541, 543.

*Coenosia albifrons* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII (3-4) p. 276. . . . Coquillett, Proc. Wash. Acad. Sci., 1900 p. 446. . . . Stein, Katal. Paläark. Dipt., 1907 III p. 736. . . . Stein, Wien. Ent. Zeitg., 1908 XXVII (1) p. 3.

*Limnospila albifrons* Schnabl, Wien. Ent. Zeitg., 1902 XXI p. 111. . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 562. . . . Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII No. 1719 p. 561. . . . Schnabl and Dziedziński, Abh. K. Leop.-Carol. Akad. Naturforsch., 1911 XCV Nr. 2 p. 142. . . . Stein, Arch. f. Naturgesch., 1914 (1913) A (8) p. 28. . . . Stein, Arch. f. Naturgesch., 1916 (1915) A (10) p. 112. . . . Ringdahl, Ent. Tidskr., 1918 XXXIX p. 160. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 58. . . . Séguy, Faune de France, 1923 (6) p. 194. . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 230. . . . Hallock, Circ. 103 N. J. Dept. Agr., 1926 p. 16. . . . Johnson, Insect Fauna, Biol. Surv. Mt. Desert Region, 1927 p. 208. . . . Karl, Tierwelt Deutschlands, 1928 XIII p. 207. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835.

The species may be readily distinguished from allied forms by its notably broad frons and whitish pruinose frontal triangle, resembling in this respect specimens of *Pseudolimnophora nigripes* (Robineau-Desvoidy). From *Phyllogaster unicus* (Stein), to which it also bears a superficial resemblance on account of its small size, the species may be distinguished by the nondepressed character of the second antennal segment, by the restriction of the arisal thickening to extreme base, and by the relatively weaker development of the caudal pair of ocellar bristles.

Alaska, 9 ♂, 3 ♀, Anchorage, June 16 1921; 3 ♂, July 19 1921: 3 ♂, 2 ♀, Seward, July 24 1921: 1 ♂, Skagway, June 7 1921 (J. M. Aldrich): 2 ♀, Saldovia, July 21 1899 (T. Kincaid) (U. S. N. M.).

British Columbia, 1 ♀, Prince Rupert, Aug. 16 1919 (H. G. Dyar).

Maine, 1 ♂, Narrows, Mt. Desert, Aug. 13 1920 (U. S. N. M.).

Nevada, 1 ♀, Steamboat, May 13 1917 (H. G. Dyar) (U. S. N. M.).

Utah, 1 ♂, Salt Lake City, July 18-20 1917 (U. S. N. M.).

#### Genus *Pseudocænusia* Stein

*Cænusia* Stein, Wien. Ent. Zeitg., 1902 XXI (2-3) p. 35. . . . Stein, Katal. Paläarkt. Dipt., 1907 III p. 740.



*Macrorchis* Stein, Arch. f. Naturgesch., 1914 (1913) A (8) p. 9.  
*Pseudocænusia* Stein, Arch. f. Naturgesch., 1916 (1915) A (10)  
pp. 113, 220. . . . Stein, Arch. f. Naturgesch., 1919 (1917)  
A (1) p. 95. . . . Stein, Arch. f. Naturgesch., 1920 (1918)  
A (9) p. 60. . . . Karl, Tierwelt Deutschlands, 1928 XIII  
pp. 204, 207. . . . Ringdahl, Ent. Tidskr., 1929 L p. 13.  
. . . Collin, Ent. Month. Mag., 1930 LXVI pp. 228, 229.

Genotype *Aricia longicauda* Zetterstedt.

The genus was described by Stein (39) in 1916 for the reception of the European species *Aricia longicauda* Zetterstedt and *Pseudocænusia abnormis* Stein. The former species had heretofore been placed in *Cænusia*, and had been cited more recently by Stein (38) as being linked to *Macrorchis* Rondani. In 1928 Karl (7) designated *longicauda* as the genotype.

The genus is evidently represented by species that are rather aberrant in appearance, a deduction that is further supported by the evidence provided by the finding of two additional forms from North America. In many respects the genus may be considered as related to *Macrorchis* on the one hand, and to *Limnospila* on the other. With the exception of the European species *abnormis* the males possess many notably long fine bristles clothing the coxæ, on the ventral region of sternopleura, and at base of posteroventral surface of mid and hind femora, the tip of the bristles in many cases curling. In addition the fore tibia possesses a short mid anterodorsal bristle and the mid femur a preapical bristle on anterior surface.

Diagnostic characters: Frontal vitta narrowed, tapering cephalad, at narrowest width scarcely, if any, greater than maximum breadth of both parafrontals when viewed from above: caudal pair of ocellar bristles weakly developed, not longer than presutural acrostical bristles, directed forward: third arisal segment restricted at base to narrower proportions than second arisal segment: hind tibia with a stout bristle at middle of anterodorsal surface, as in *Cænusia*: abdomen in male subconical, hypopygium robust, fifth sternum with broad pendant processes.

#### KEY TO SPECIES

1. Hind tibia with a stoutly developed apical posterodorsal bristle, which is longer than diameter of tibia where situated; hind femur with no

duplicating bristle situated ventrad of distal bristle of anterodorsal series: male with fifth sternum deeply incised to beyond middle of plate; ventral border of basal sclerite of hypopygium polished.

*nigriventris* new sp.

- Hind tibia with apical posterodorsal bristle fine and setulose, shorter than diameter of tibia where situated; hind femur with a duplicating bristle situated ventrad of distal bristle of anterodorsal series; males with fifth sternum incised to about middle of plate; basal sclerite of hypopygium not polished ventrad ..... 2
- 2. Hind tibia with a strongly developed apical posteroventral bristle, with 1 mid anteroventral bristle; hind tarsi not longer than hind tibiæ; male with processes of fifth sternum truncated ..... *brevicauda* new sp.
- Hind tibia with apical posteroventral bristle weakly developed, setulose; with 2 or 3 mid anteroventral bristles; hind tarsi longer than hind tibiæ; male with processes rounded along caudal margin.

*longicauda* Zetterstedt

#### ***Pseudocoenosia nigriventris* new species**

Male blackish; head with dense velvety pruinescence on parafrontals and parafacials; frontal vitta with whitish dust when viewed from in front; antennæ and palpi black; proboscis polished. Thorax subshining; lightly pruinescent, with trace of darker streaks along planes of dorsocentral bristles. Abdomen highly shining, with trace of pruinescence, deep black, with little trace of dorsal markings: ventral region of basal sclerite of hypopygium and of ninth tergum (anal sclerite) and the greater part of the processes of fifth abdominal sternum polished. Legs black, highly shining; pulvilli tinged. Wings with trace of yellowish tinge along anterior border and at base. Lower calyptre faintly yellowish, upper calyptre whitish. Halteres yellowish.

Frons at narrowest slightly wider than length of third antennal segment; frontal vitta wider than the maximum breadth of either parafrontal; parafacials at base of antennæ fully as wide as, and cheeks as high as, width of third antennal segment, the former slightly narrowed ventrad. Arista pubescent, longest hairs fully equal to twice diameter of second aristal segment. Eyes broadly ovoid. Mesonotum with three pairs of postsutural dorsocentral bristles; caudal pair of acrostical bristles not longer than the presutural pairs. Abdomen stoutly developed, deep and truncated, greatest depth about equal to three-quarters its length; hypopygium large, ventral region of basal sclerite of hypopygium expanded slightly into two horizontal lobes; fifth sternum deeply incised, the processes large and pendant, the apical region with numerous well developed bristles directed caudad, otherwise clothed with fine longish bristles and setulæ.

Fore tibia with a mid anterodorsal and a stronger mid posterior bristle; mid femur with a preapical bristle on anterior surface, and with 3 or 4 long fine bristles on proximal half of posteroventral surface: mid tibia with 1 mid anterodorsal, 1 mid posterodorsal and a shorter bristle proximad: hind femur with 7 anteroventral bristles, of which the prebasal bristles are longest and

strongest and those at base fine and slender, with four long bristles on proximal half of posteroventral surface, which become finer developed basad; hind tibia with 1 mid anteroventral bristle, with 1 strong bristle at middle of anterodorsal surface and with a shorter bristle proximad, with 1 short posterodorsal bristle on proximal half, with apical posterodorsal bristle well developed, and with apical posteroventral bristle weakly developed, setulose. Pulvilli elongate, claws slender, longish. Wings with *r-m* cross vein situated opposite the point of union of *R*<sub>1</sub> with costa; section of *M*<sub>1+2</sub> between *r-m* and *m-cu* cross veins about equal in length to the section immediately proximad. Length, 5.25 mm.

Female similar to male, eyes more widely separated, ocellar triangle extended cephalad to three-quarters length of frontal vitta. Parafrontals narrower. Legs with similar chaetotaxy except that the proximal bristles on posteroventral surface of mid and hind femora are shorter. Length, 5.5 mm.

Type and allotype, Rattlesnake Cr., Tulare Co., Cal., 9000 ft., Aug. 2 1915. (A. N. S. P.)

The species may be distinguished from *longicauda* and *brevicauda* by its more intense black coloration, by the strongly developed apical posterodorsal bristle on hind tibia, and by the presence of only one preapical bristle on anterodorsal surface of hind femur. Owing to the condition of the specimens I am unable to state definitely whether the species has one or two pairs of normal reclinate parafrontal bristles. In all three specimens there are indications that this species may possess a second pair of reclinate bristles. The problem is further complicated by the fact that there is a tendency in the genus for variations to occur affecting the development and number of bristles forming the parafrontal series.

#### ***Pseudocoenosia brevicauda* new species**

Male similar in color and marking to *longicauda*. Parafrontals and parafacials velvety pruinose, face and cheeks duller; proboscis polished; antennæ and palpi blackish; frontal vitta, viewed from in front, with light brownish dust. Thorax grayish black, more densely dusted than abdomen; mesonotum unmarked. Abdomen blackish, subshining, with trace of dorso-central vitta on terga 1+2, 3, and 4; fifth tergum and basal sclerite of hypopygium largely fuscous; fifth sternum polished along inner and caudal borders of processes. Legs blackish, femora concolorous with abdomen; pulvilli tinged. Wings tinged with yellow anteriorly and basad; calyptræ paler than base of wing, whitish, lower scale tinged; halteres reddish yellow, with trace of darker tinge.

Head with frons narrower than in *longicauda*, at narrowest scarcely equal

to length of third antennal segment; frontal vitta narrower than either parafacial. Parafacials in profile, at base of antennae, slightly wider than breadth of third antennal segment. Cheeks about as high as width of third antennal segment. Eyes oval in outline; the ventral occipital region of head restricted, not prominently produced. Arisal hairs not longer than diameter of second arisal segment. Mesonotum with three pairs of postsutural dorso-central bristles. Abdominal vestiture and structure similar to that of *longicauda*, the most noteworthy difference being the more quadrate outline of the processes, the mesocaudal angle being rectangular and thus the inner and caudal margins straight.

Fore coxæ armed with an inner and outer series of strong bristles on anterior surface; fore tibia with a short mid anterodorsal and a stronger bristle on posterior surface at about the same level; mid femur with 3 or 4 longish bristles on proximal half of posteroventral surface, with a preapical bristle on anterior surface; mid tibia with 1 mid anterodorsal and 1 weaker mid posterodorsal bristle; hind femur with 4 or 5 well spaced bristles on anteroventral surface, those proximad finer and equally long or longer, with 4 or 5 fine long bristles on proximal half of posteroventral surface, with 2 adjacent preapical bristles on anterodorsal surface; hind tibia with 2 anteroventral, with 1 strong mid anterodorsal bristle, and a shorter weaker bristle proximad, with a short mid posterodorsal bristle, with apical posterodorsal bristle setulose, and with apical posteroventral bristle robust. Tarsal claws and pulvilli well developed. Wings with *r-m* cross vein opposite a point on costa that is distad of its union with *R*<sub>1</sub>. Section of *M*<sub>1+2</sub> between *r-m* and *m-cu* cross veins slightly shorter than the immediate section proximad. Length, 5 mm.

Type, ♂ Jasper, Alta., July 25 1926 (J. McDunnough) (C. N. C.).

The species, as indicated by the male sex, closely resembles *longicauda*, from which it may be separated by the presence of a stoutly developed apical bristle on posteroventral surface of hind tibia; by the truncated outline of the processes of fifth sternum, and by their polished appearance; by the narrower frons; and by the presence of an inner series of strong bristles on anterior surface of fore coxæ. In *longicauda* the apical posteroventral bristle on hind tibia is setulose in development, the processes of fifth sternum are rounded in outline along the caudal border, and the fore coxæ are largely clothed with fine setulæ on anterior surface.

#### ***Pseudocœnosia longicauda* (Zetterstedt)**

?*Aricia longisquama* Zetterstedt, Dipt. Scand., 1845 IV p. 1622.  
*Aricia longicauda* Zetterstedt, Dipt. Scand., 1860 XIV p. 6230.



*Cænusia octosignata* Strobl not Rondani, Verh. zool.-bot. Gesellsch., Wien, 1893 XLIII p. 267.

*Cænusia longicauda* Stein, Wien. Ent. Zeitg., 1902 XXI p. 35.

. . . Stein, Wien. Ent. Zeitg., 1908 XXVII (1) p. 12. . . .

Stein, Katal. Paläark. Dipt., 1907 III p. 740.

*Cænusia rondanii* Strobl, Wiss. Mitth. Bosnien, 1900 VII p. 615.

*Macrororchis longicauda* Stein, Arch. f. Naturgesch., 1914 (1913)

A (8) p. 9.

*Pseudocænusia longicauda* Stein, Arch. f. Naturgesch., 1916

(1915) A (10) p. 113. . . . Stein, Arch. f. Naturgesch.,

1919 (1917) A (1) p. 95. . . . Stein, Arch. f. Naturgesch.,

1920 (1918) A (9) p. 60. . . . Karl, Tierwelt Deutschlands,

1928 XIII (3) pp. 204, 208. . . . Ringdahl, Ent. Tidskr.,

1929 L p. 13. . . . Collin, Ent. Month. Mag., 1930 LXVI

pp. 228-229. . . . Ringdahl, Arkiv f. Zool., K. Svensk.

Vetenskapsakad., 1930 XXIA (20) p. 2.

The species most closely resembles *brevicauda* in coloration, markings, and structure. Their distinguishing characters have been cited in the paragraphs devoted to a discussion of that species. In the series of specimens collected in Colorado I note that one female has apparently two pairs of reclinate parafrontal bristles on vertex of head. The same is true in the specimens of *nigriventris*. It is not always possible to discern the true differences between the two types of parafrontal bristles in the genus, especially if there be a second bristle directed caudad. There is ample evidence at hand to indicate that in this genus there is a tendency for variations to occur affecting the number and development of the bristles in the parafrontal series.

Alaska, ♀ Savonoski, Naknek Lake, June 19- (J. S. Hine).

Alberta, 1 ♂, 1 ♀, Banff, June 9 1922; 1 ♀, May 5 1922; 1 ♀, June 1 1922; 1 ♂, June 29 1922; 1 ♀, July 4 1922; 1 ♀, Sept. 12, 1922 (C. B. D. Garrett) (C. N. C.).

Colorado, 6 ♂, 3 ♀, Tennessee Pass, 10240 ft., July 9-; 1 ♂, July 10- (J. M. Aldrich). (U. S. N. M.).

South Dakota, 1 ♀, Sylvan Lake, July 19 1924: 1 ♀, Custer, July 17 1924. (S. D. Agr. Col.).

Genus *Macrororchis* Rondani

*Macrororchis* Rondani, Dipt. Ital., Prodr., 1877 VI (5) p. 280. . . .  
Stein, Katal. Paläark. Dipt., 1907 III p. 732. . . . Stein.  
Arch. f. Naturgesch., 1916 (1915) A (10) pp. 12, 203, 220.  
. . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) pp. 95,  
156. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9)  
p. 93. . . . Malloch, Ent. News, 1921 XXXII p. 106. . . .  
Séguy, Faune de France, 1923 (6) pp. 64, 180. . . . Karl,  
Tierwelt Deutschlands, 1928 XIII (3) pp. 204, 206. . . .  
Curran, Fam. Gen. N. A. Dipt., 1934 p. 396.

Genotype *Musca meditata* Fallén.

The genus was erected in 1877 by Rondani (27) with *Musca meditata* Fallén as type. This species has, so far as I know, remained the only valid representative of the genus in Europe. There are three North American forms recorded, namely *Anthomyia alone* Walker, *Cænusia ausoba* Walker, and *Cænusia majuscula* Coquillett. A fourth species is herein added to the list, having been collected by Dr. J. M. Aldrich in Alaska.

The genus may be distinguished from *Pseudocænusia*, which it most closely resembles, by having the caudal pair of ocellar bristles directed outwards and not forward, by having the lower stigmal bristle directed downward, and not upward, and by the opaque, grayish pruinose prosternum, which in *Pseudocænusia* is shining and polished.

On account of the presence of a so-called second pair of presutural dorsocentral bristles in occasional specimens of *Cænusia*, difficulties will undoubtedly arise in attempts to dissociate such specimens from this genus, the more so since such diagnostic characters as the proportionate development of the lower calyptral scale and the relative extent of the anal vein tend also to be variable factors. In these respects I have had difficulty in placing the new species herein recorded, but have concluded that it may be considered as being more closely associated with this genus than, for instance, with the *Hoplogaster* or *Limosia* segregates of *Cænusia*, where it would otherwise be included.

Diagnostic characters: Lower calyptra strongly protruded beyond margin of upper; mesonotum with two pairs of well developed presutural dorsocentral bristles; caudal pair of ocellar

bristles directed outwards; lower stigmal bristle on thoracic pleura directed downward; arista slender, slightly thickened at basal region.

#### KEY TO SPECIES

1. Mid and hind femora entirely yellow; abdomen with no paired markings; ninth tergum (anal sclerite) of male with numerous strong bristles .....2
- Mid and hind femora at least fuscous or blackish in part; abdomen with paired marks; male with at most weak bristles on ninth tergum .....3
2. Fore femur entirely yellow; second antennal segment normal in appearance, not noticeably appressed on proximal half to slender proportions, the segment shorter than half distance between oral vibrissæ; hind femur with 1 preapical anterodorsal bristle (the distal bristle of antero-dorsal series); hind tibia with one longish apical anteroventral bristle.  
*ausoba* Walker
- Fore femur more or less blackened along the dorsal surface; second antennal segment markedly appressed on proximal half to slender proportions, the segment as long as half distance between oral vibrissæ; hind femur with 2 adjacent preapical bristles on anterodorsal surface; hind tibia with 2 subequal robust apical anteroventral bristles.....*alone* Walker
3. Mid and hind femora with no preapical posteroventral bristle, situated at a level with the preapical posterodorsal bristle; distal section of  $M_3 + Cu_1$ , to wing margin, shorter than *m-cu* cross vein; all femora entirely blackened on proximal three-fourths .....*majuscula* Coquillett
- Mid and hind femora with a preapical posteroventral bristle, situated at a point opposite the preapical posterodorsal bristle; distal section of  $M_3 + Cu_1$ , to wing margin, as long as *m-cu* cross vein; mid and hind femora with at least a trace of yellowish proximad .....*comita* new sp.

#### Macrorchis ausoba (Walker)

*Anthomyia ausoba* Walker, List Dipt. Brit. Mus., 1849 IV p. 938.

. . . Walker, Canad. Ent., 1871 III p. 144. . . Osten Sacken, Misc. Coll. Smithsn. Inst., 1878 (270) p. 169.

*Cænusia aurifrons* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII (3-4) p. 260. . . Smith, Ann. Rept. State Board Agric. 1899 Suppl., 1900 p. 682. . . Stein, Zeitschr. f. Hymen. Dipt., 1901 (4) p. 187.

*Cænusia ausoba* Stein, Ann. Mus. Nat. Hungar., 1904 II p. 488. . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 560. . . Smith, Ann. Rept. N. J. State Museum 1909, 1910 p. 793. . . Britton, Bull. 31 Conn. Geol. Nat. Hist. Surv., 1920 p. 199. . . Cole and Lovett, Proc. Col. Acad. Sci., 1921 XI No. 15 p. 314.

*Macrorchis ausoba* Stein, Arch. f. Naturgesch., 1919 (1917) A (1) 156. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 93. . . . Johnson, Proc. Boston Soc. Nat. Hist., 1925 XXXVIII (2) p. 94. . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 236. . . . Johnson, Insect Fauna, Biol. Surv. Mt. Desert Region, 1927 p. 211. . . . Hockett, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 835.

The species has undoubtedly a wide distribution in North America, occurring in marshy and swampy areas. It agrees with *alone* and *majuscula* in having the distal section of vein  $M_{.3} + Cu_{.1}$  scarcely as long as *m-cu* cross vein, and in the possession of a rather noticeable pruinose spot at apex of second antennal segment. However *ausoba* differs from both species in having the fore femur entirely yellow, and in possessing only one long apical anteroventral bristle on hind tibia.

British Columbia, 1 ♂, Vernon, June 4 1924: 1 ♀, Agassiz, July 15 1926 (R. Glendenning).

Illinois, 1 ♂, Algonquin, Aug. 26 1894.

Indiana, 2 ♂, Chesterton, June 2 1916: 1 ♀, Vincennes, May 9—: 1 ♀, Michigan City, Aug. 18 1914.

Maine, 1 ♂, Bar Harbor, Aug. 5 1918 (C. W. Johnson): 2 ♂, Sebago Lake, Sept. 9 1914.

Manitoba, 2 ♀, Aweme, July 10 1926 (R. D. Bird).

Massachusetts, 3 ♂, Beverly, June 3 1876; 1 ♂, July 4 1869; 1 ♂, 1 ♀, June 2 1876; 1 ♀, June 15 1876; 1 ♀, June 19 1867 (U. S. N. M.).

Minnesota, 1 ♀, New Ulm, May 20 1916.

Newfoundland, 1 ♂, Stephenville; 1 ♀, Bay St. George, July; 1 ♂, Port aux Choix.

New Hampshire, 1 ♂, White Mts., (Morrison) (U. S. N. M.): 1 ♀, Mt. Washington, (Slosson): 1 ♀, Franconia, (Coquillett).

New York, 2 ♂, Riverhead, Long Island, Aug. 10 1927; 1 ♂, Sept. 26 1929; 1 ♀, Oct. 2 1927; 1 ♀, June 27 1926: 1 ♂, Ithaca, June 10 1920: 1 ♂, Saranac Lake, Aug. 26 1916: 1 ♀, Schenectady, June 30 1929: 2 ♀, Wells, Aug. 25 1923.

Ohio, 2 ♀, Cuyhga Fls., Aug. 10 1904.



Ontario, 1 ♂, Toronto, June 13 1896; 1 ♂, July 7 1896 (U. S. N. M.). 3 ♀, Whitby, July 6 1926 (C. H. Curran): 1 ♀, Lyn, July 7 1926 (G. S. Walley).

Quebec, 1 ♀, Fairy Lake, June 1 1927 (W. J. Brown): 1 ♀, Aylmer, Sept. 28 1924 (C. H. Curran).

South Dakota, 1 ♂, 2 ♀, Brookings, June 18 1891 (U. S. N. M.): 1 ♂, Erwin, June 1908.

Wisconsin, 1 ♂, Brule River, Doug. Co., Aug. 23 1912 (Witmer Stone) (A. N. S. P.).

### **Macrorchis alone** (Walker)

*Anthomyia alone* Walker, List Dipt. Brit. Mus., 1849 IV p. 941.

. . . Osten Sacken, Misc. Coll. Smithsn. Inst., 1878 (270) p. 169.

*Macrorchis alone* Hockett, Canad. Ent., 1934 LXVI p. 133.

Male allotype, similar in coloration and marking to *ausoba*, except that the mesonotum has a narrow brownish dorsocentral vitta and the fore femur has a blackish mark along posterodorsal surface. Structurally more robust than *ausoba*: frons wider than one third maximum width of head, when viewed from in front; width of parafacials at base of antennæ nearly equal to one half maximum breadth of eye; height of cheek about one third that of eye; length of second antennal segment about half that of third antennal segment, noticeably attenuated proximad. Arisal hairs slightly longer than diameter at base of arista. Hypopygium similar to that of *ausoba*, processes of fifth sternum more densely clothed with longer bristles and setulæ along ventral (inner) border.

Legs stronger bristled, and tarsi stouter developed than in *ausoba*. Fore tibia with a well developed apical posteroventral bristle; hind femur with an additional preapical bristle near anterodorsal surface; hind tibia with 3 well developed apical bristles on dorsum, and with 2 longish bristles at apex of anteroventral surface; otherwise the bristling of legs similar to that of *ausoba*. Length, 12 mm.

Allotype, Natashquan, P. Q., Aug. 1 1929 (W. J. Brown) (C. N. C.).

This species has been cited by Stein (34) (41) as probably a

synonym of *ausoba*, and as such has been commonly considered. I am of the opinion that the species is distinct from *ausoba*, and can be distinguished by the blackened dorsal patch of infuscation on fore femur; by the additional long duplicating bristle at apex of anteroventral surface of hind tibia, and on the preapical region of the anterodorsal surface of hind femur; and by the more noticeable attenuation of the second antennal segment, proximad.

Alaska, 1 ♂, Fairbanks, July 1 1921; 1 ♂, July 3 1921; 1 ♂, July 4 1921: 1 ♀, Anchorage, July 19 1921; 1 ♂, July 20 1921 (J. M. Aldrich) (U. S. N. M.).

Alberta, 1 ♂, Lethbridge, June 23 1924; 2 ♀, July 2 1924 (H. E. Gray).

Manitoba, 1 ♂, Teulon, July 8 1922 (A. J. Hunter).

Quebec, 1 ♂, 2 ♀, Natashquan, Aug. 1 1929 (W. J. Brown) (C. N. C.).

#### ***Macrorchis majuscula* (Coquillett)**

*Cænoscia majuscula* Coquillett, Invert. Pacif., 1904 1 p. 34.

*Macrorchis majuscula* Malloch, Trans. Amer. Ent. Soc., 1918 XLIV No. 782 p. 286. . . . Stein, Arch. f. Naturgesch., 1919 (1917) A (1) p. 156. . . . Stein, Arch. f. Naturgesch., 1920 (1918) A (9) p. 93.

The species differs notably from others in having all femora entirely blackened on proximal three-fourths, and in the possession of two closely adjacent bristles at middle of hind tibia, as in *Cænoscia tigrina* (Fabr.). As in *alone*, the apical posteroventral bristle on fore tibia, in male, is well developed, and there is, in both sexes, a second long anteroventral bristle at apex of hind tibia. From *comita* the species may be further distinguished by the lack of a preapical posteroventral bristle on mid and hind femora, and by the restricted distal section to  $M_{.3} + Cu_{.1}$ , which is shorter than  $m-cu$  cross vein.

California, 1 ♂, Santa Clara Co., (Baker). (U. S. N. M.): 1 ♂, Pacific Grove, May 7 1906: 1 ♀, Redwood City, April 19 1906: 2 ♀, Salt Marshes, Palo Alto, April 20 1906 (Z. M. U. B.).

#### ***Macrorchis comita* new species**

Male blackish; frontal vitta blackish with pale brownish pruinescence; parafrontals grayish, as occiput, with little or no pruinescence; parafacials

and cheeks more highly whitish pruinulent, face gray; antennæ blackish, second segment with whitish dust on inner surface, and with pruinulent spot at apex; palpi blackish, shining; proboscis polished. Thorax grayish black, subshining, concolorous with occipital region of head, with macrochaetæ set in fuscous spots, with brownish infuscation between the planes of dorso-central bristles, from which 3 denser marked vittæ appear, arising along the planes of acrostical and dorsocentral bristles; scutellum infuscated at basal angles. Abdomen concolorous with thorax, with four pairs of widely spaced subtriangular or roundish fuscous marks; processes of fifth sternum shining along inner border. All coxæ blackish, as thorax; trochanters yellowish. Fore femur largely blackish, mid and hind femora more or less blackish infuscated throughout distal half, yellowish proximad; all tibiæ yellowish, tarsi blackish, pulvilli brownish tinged. Wings faintly tinged with yellow along cephalic border and proximad; calyptræ whitish, margins yellowish tinged. Halteres yellow.

Head with frons nearly one-third maximum width of head, ocellar triangle extended cephalad to near center of frontal vitta; width of parafacials at base of antennæ about equal to one-third maximum width of eye, narrowed ventrad to about equal to width of third antennal segment; height of cheek nearly one-third that of eye, ventral margin of eye not reaching a level with oral vibrissæ; second antennal segment about half as long as third segment, slightly but perceptibly attenuated proximad; hairs on arista not longer than basal diameter of arista; ventral half of occipital region of head prominently produced; palpi slender, clavate. Abdomen broadly conical, compact, deeper caudad, with numerous well developed discal bristles, in appearance resembling that of *Hoplogaster morrisoni* Malloch. Hypopygium not large, basal sclerite well developed, with numerous bristles of about equal size to those along caudal margin of tergum 5; ninth tergum (anal sclerite) inconspicuous, not globose, with a few fine setulose bristles and hairs; processes of fifth sternum broad, thickened and shining along inner border and apical region, on which arise numerous erect slender bristles and hairs, the former becoming stronger apicad. Sterna broader than long.

Fore tibia with a slender mid posterior bristle; mid femur with a series of short bristles on proximal half of anteroventral surface, with a series of 5 to 7 widely spaced longer bristles on posteroventral surface, from base to near apex, with a preapical bristle on anterior surface; mid tibia with a mid anterior and posterior bristle at about the same level, the former weaker than the latter; hind femur with 5 or 6 bristles on anteroventral and on posteroventral surfaces, from base to near apex, the strongest and longest bristles being situated toward the proximal region of femur; hind tibia with a mid anteroventral, a strong mid anterodorsal and a short mid posterodorsal bristle. Tarsi slender, hind tarsus about as long as hind tibia, tarsal claws well developed, pulvilli robust, elongate. Length, 5.5 mm.

Female similar to male, the wings more uniformly tinged; parafacials and cheeks slightly narrower; third antennal segment tapered distad; second antennal segment normal in appearance, scarcely equal in length to half that of

third antennal segment. Discal bristles of abdomen short and weakly developed, scarcely longer than marginal bristles of their respective terga; abdominal sterna 2 to 5 longer than wide; fifth tergum with a sparse series of weak marginal bristles. Fore tibia with a weak mid anterodorsal and a mid posterior bristle; mid and hind femora and hind tibia with bristling similar to male; mid tibia with a mid anterior and posterior bristle, of about equal size; pulvilli and claws well developed. Wings with veins  $R_{4+5}$  and  $M_{1+2}$  divergent at wing margin. Length, 5.75 mm.

Type, ♂ Healy, Alaska, June 23 1921; Allotype, ♀ same locality, June 26 1921 (J. M. Aldrich) (U. S. N. M.).

The species does not readily conform to the general characteristics of the genus, as I accept them, the markings, chaetotaxy, and structure of the parts having more in common with *Cœnosia* than *Macrorchis*. However the above specimens possess two well developed pairs of presutural dorsocentral bristles, and hence with the present keys, such specimens may no doubt be more readily traced to this genus for purposes of identification than to elsewhere. The species bears a resemblance to *Hoplogaster morrisoni* Malloch, but that species has only one pair of presutural dorsocentral bristles and the lower calyptral scale is not larger than the upper.

#### CORRIGENDA

*Tetramerinx femorata* Malloch (9) is more closely allied to the species comprising the genus *Limnophora sens.-str.* Malloch (13) has erected the genus *Bucephalomyia* for its reception.

*Tetramerinx brevicornis* Malloch (10) and *Tetramerinx uralica* Stein (42) belong more correctly to the group *Spilogona* Robineau-Desvoidy.

*Phyllogaster nudiseta* (Stein) in a list of the insects of New York (8) refers undoubtedly to the species *Cœnosia nudiseta* Stein.

#### ACKNOWLEDGMENTS

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University (C. U.), Zoological Museum of the University of Berlin (Z. M. U. B.).

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## PLATE IV

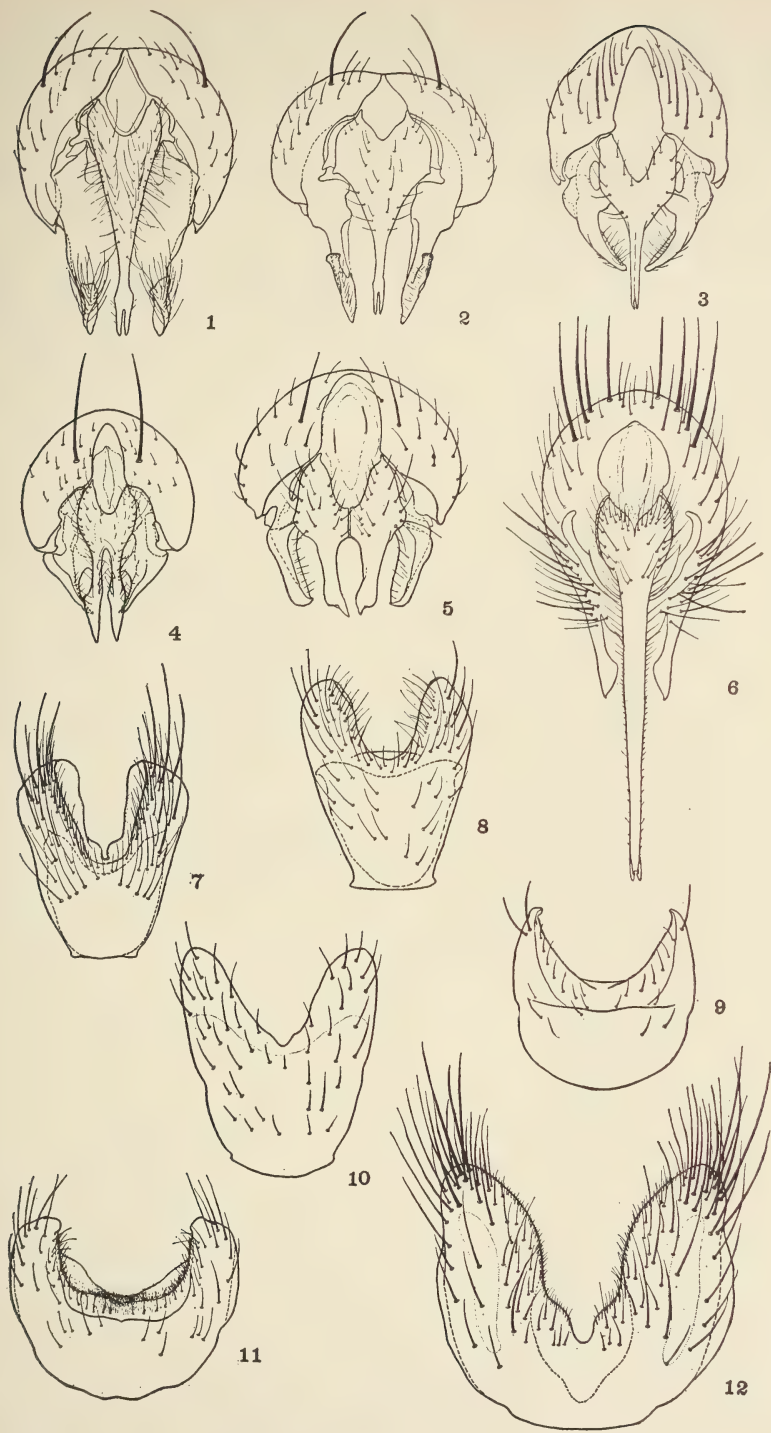
Dorsal or caudal aspect of male copulatory appendages.

- Figure 1. *Phyllogaster cordyluroides* Stein
- Figure 2. *Phyllogaster mallitosus* new species
- Figure 3. *Phyllogaster unicus* (Stein)
- Figure 4. *Phyllogaster littoralis* Malloch
- Figure 5. *Limnospila albifrons* (Zetterstedt)
- Figure 6. *Macrochis ausoba* (Walker)

Ventral aspect of fifth abdominal sternum in male.

- Figure 7. *Phyllogaster cordyluroides* Stein
- Figure 8. *Phyllogaster mallitosus* new species
- Figure 9. *Phyllogaster unicus* (Stein)
- Figure 10. *Phyllogaster littoralis* Malloch
- Figure 11. *Limnospila albifrons* (Zetterstedt)
- Figure 12. *Macrorchis ausoba* (Walker)





MUSCIDÆ

## PLATE V

Lateral aspect of male copulatory appendages.

Figure 13. *Phyllogaster cordyluroides* Stein

Figure 14. *Phyllogaster mallitosus* new species

Figure 15. *Phyllogaster littoralis* Malloch

Figure 16. *Phyllogaster unicus* (Stein)

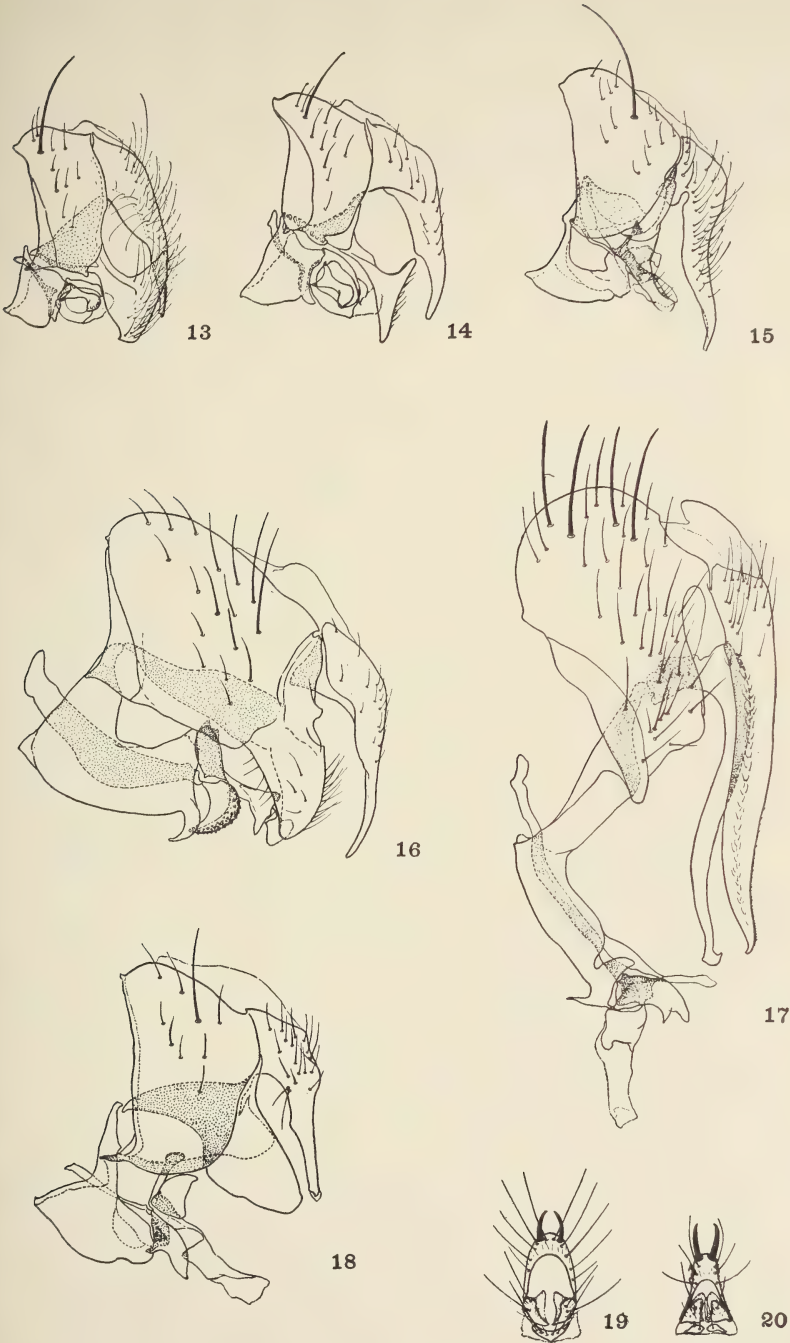
Figure 17. *Macrorchis ausoba* (Walker)

Figure 18. *Limnospila albifrons* (Zetterstedt)

Dorsal aspect of anal sclerites in female.

Figure 19. *Phyllogaster cordyluroides* Stein

Figure 20. *Phyllogaster mallitosus* new species







## THE GENUS *DIOGMITES* IN THE UNITED STATES OF AMERICA WITH DESCRIPTIONS OF NEW SPECIES (DIPTERA: ASILIDÆ)

BY STANLEY W. BROMLEY, PH.D.

The genus *Diogmites* Loew contains the species which have been placed in the genus *Deromyia* Phillippi by most writers in this country. Many years ago, Williston expressed the belief that *Diogmites* and *Deromyia* were synonymous and this opinion was followed by most North American authors, in spite of Osten-Sacken's assertion that the two were entitled to at least subgeneric separation. In 1928, Malloch (Notes on Australian Diptera, XIV, Proc. Linn. Soc. N. S. W. liii, 3, p. 299) after a careful examination of the genotypes, declared that *Deromyia* and *Diogmites* were not congeneric, calling attention to the facts that (1) *Deromyia* has only a few microscopic hairs on the ocellar region, while *Diogmites* has there at least two strong bristles; (2) *Deromyia* has the front tibial spur blunt at the apex and opposed to a short ridge or wedge-shaped elevation on the basal portion of the ventral surface of the fore metatarsus, while *Diogmites* has the spur sharp at the tip and resting in a depression surrounded in part by a number of short stout spines; (3) *Deromyia* has the basal two antennal segments subequal in length while *Diogmites* has the basal one much shorter than the second; (4) *Deromyia* has fine hairs above at or just beyond the middle of the third segment, while in *Diogmites* there are hairs on almost the entire basal half of the upper surface; (5) *Deromyia* has the apex of the fourth posterior cell pointed, with the vein closing it at least twice as long as the cross-vein above it, while *Diogmites* has the apex of the fourth posterior cell truncate with the vein closing it as long as the cross-vein above it.

In 1929, Engel (Konowia, VIII, 4) remarking on Coquillett's dictum (Type Species of American Diptera, Proc. U. S. N. Mus., vol. 37, p. 533, 1910) that *Diogmites* equals *Deromyia*, called attention to the fact that *Deromyia gracilis* Phillippi bore a cylindrical "griffel" ending in a sharp spine at the tip of the third

antennal segment, whereas *Diogmites* has only a short bristle. In addition, *Deromyia* has the scutellum without bristles, while in *Diogmites* there are two strong bristles on the margin.

I have examined specimens of *D. fuscipennis* (Blanchard) in preparing my paper on the Asilidæ of Patagonia and South Chile (Diptera of Patagonia and South Chile (British Museum (Nat. Hist.) part V-fasc. 3, 265–267, 1932) and at the time came to the conclusion that the two genera were distinct, the slender *Deromyia* being more suggestive of the African *Neolaparus* than our North American *Diogmites*.

GENOTYPES: We should therefore consider the genera distinct: *Deromyia* Philippi (1865, Verh. zool.-bot. Ges. Wien, 15, 705) of which *gracilis* Philippi (1865, Verh. zool.-bot. Ges. Wien, 15, 705) is the genotype; and *Diogmites* Loew, Cent., VII, 36, 1866 of which *platypterus* Loew, Cent., VII, 36, 1866, is the genotype.

The species of *Diogmites* occurring in the United States are generally rather slender, bare species with the mystax confined to the oral margin. Most are pale yellowish or reddish in color with the long, slender but strong legs bearing coarse bristles. The fourth posterior cell is always closed, usually at a distance from the wing margin. There is generally considerable difficulty in distinguishing the species represented by dried, shrivelled, discolored specimens in a collection. In the field, the distinct colors, different flight habits and ecology render them easy of identification to the collector, but these differences become obscure once the specimen has dried, faded or changed color in an insect cabinet. Fortunately, there is not the dimorphism and dichromatism exhibited by the species of *Saropogon* (*D. discolor* Loew is the only *Diogmites* with which I am familiar that exhibits to any extent a pronounced dichromatism in the sexes). In general it may be said that individuals of *Saropogon* look different but prove to be the same species, while individuals of *Diogmites* look alike but prove to be different!

Specimens of *Diogmites* (in a collection) tend to "grease" which completely obscures the coloration and pollinose condition and renders identification well nigh impossible. In preparing the review of this genus I have not used greased specimens in making descriptions. Determination of any specimen in this

genus should not be attempted until it has been degreased. This may be accomplished by immersing the greased specimen, pin, label and all (do not place a colored label in xylene as this will extract certain constituents from the dye) in xylene or benzene and allowing it to remain there four or five days before removing and drying. This treatment usually restores the color and pollinose condition.

Species of *Diogmites* are frequently very abundant in individuals. They are usually active and voracious and in spite of their fragile appearance will attack and overcome such formidable stinging insects as bees and wasps. In fact, the favorite prey of most species is aculeate Hymenoptera. Some species are quite destructive to honey-bees. It is an interesting sight to watch the capture of a large wasp by a species such as *Diogmites symmachus*. The fly siezes the wasp in flight or picks it off a flower and both fall to the ground, the wasp struggling desperately and trying to make use of its fatal sting. The *Diogmites* clutches its prey with a vise-like grip, holding it off at arms length so the poisonous sting cannot reach its body, and anchors itself with one leg to a stone or plant. The wasp soon becomes exhausted by its struggles and the grip of the fly tightens while, like an octopus, the *Diogmites* slowly draws its victim closer until a rapid thrust of its beak, usually behind the head of the wasp, puts an end to the struggle. In this way the flies are able to conquer bees and wasps larger than themselves.

In Texas *D. symmachus* and *angustipennis* are destructive to honey bees. Other species of more or less importance as enemies of the domestic bees are *D. discolor* in the Central States; *D. umbrinus* in New England; *D. properans*, *D. salutans*, *D. esuriens* and *D. neoternatus* in the Southeastern States and *D. grossus* in the arid West. Even the small *D. misellus* was reported as capturing a honey-bee in a letter written to me by Mr. C. S. Brimley of Raleigh, North Carolina.

#### SYNONYMY

*Rufescens* Macquart (Hist. Nat. Dipt. I, 295, 1834) and *basalis* Walker (Dipt. Saund., 95, 1856) are undeterminable. It seems quite probable that both are the same as *discolor* Loew (Cent.,

VII, 37, 1866) and if this should be proven *rufescens* would have priority. *Herennius* Walker, List II, 339, 1849, may be the same as *umbrinus* Loew (Cent., VII, 43, 1866), but here again this name should be disregarded as the types of both Walker's *basalis* and *herennius* are lost. *Bilineata* Loew (Cent., VII, 40, 1868) I am unable to distinguish from *discolor* Loew. The former was recorded from Cuba, however, and has not been collected since the type. A paratype of *D. coloradensis* James (Amer. Mus. Novitates 596, 2, 1933) sent to me by Mr. Wilcox is very close to *D. perplexus* Back (Trans. Am. Ent. Soc. XXV, 360, 1909) but I think may be separated on the basis of the color of the fine hairs on the abdomen.

#### KEY TO THE UNITED STATES DIOGMITES

1. Mesonotum with three velvety-black lines contrasting with the light pilose condition of the rest of the disc ..... 2  
     Mesonotum otherwise, the mesonotal lines where developed not strongly contrasting ..... 8
2. Abdomen more or less coarctate, the constriction coming between the 2nd and 3rd segments ..... 3  
     Abdomen not at all coarctate ..... 5
3. Abdomen only slightly coarctate, the median black stripe of the thoracic dorsum distinctly divided its entire length by a thin pale line, abdomen pale reddish-yellow without dark bands above (Florida and neighboring S. E. states) (19-24 mm.) ..... *esuriens* n. sp.  
     Abdomen more decidedly coarctate, the median stripe of the thoracic dorsum solid black ..... 4
4. The median thoracic stripe extending black anteriorly to pronotum (Cuban species) (19-22 mm.) ..... *ternatus* Loew  
     The median thoracic stripe fading into red anteriorly (Ohio to Nebraska to Texas and Florida) (18-29 mm.) ..... *neoternatus* Bromley
5. Last 3 or 4 abdominal segments, anterior angles and venter black, rest reddish-yellow: median thoracic stripe divided; legs reddish, femora with black stripes above; wings subhyaline; abdomen very stout (Pecos River, N. Mexico) (17.6-20.5 mm.) ..... *hypomelas* Loew  
     Abdomen otherwise ..... 6
6. Wings blackish or brownish fumose; proboscis black; reddish species, the median thoracic stripe black to pronotum (Texas) (18-23 mm.) ..... *texanus* Bromley  
     Wings grayish hyaline or subhyaline ..... 7
7. Median thoracic stripe fading into red anteriorly, small, slender species (Texas to New England) (14-17 mm.) ..... *misellus* Loew  
     Median thoracic black stripe not fading into red anteriorly, wide and



solid black, abdominal tergites with dark bands more or less interrupted (Alabama and nearby S. E. states) (17-22 mm.)

*properans* n. sp.

8. Abdomen entirely black, thorax blackish-brown; wings black, legs yellowish (Nebraska and Louisiana to Illinois and S. Carolina) (16-20 mm.) ..... *platypterus* Loew  
Abdomen reddish or yellowish or if largely blackish with white pruinose lateral spots ..... 9
9. Pronotal bristles black ..... 10  
Pronotal bristles yellow or reddish ..... 12
10. Robust species, thorax dark reddish-brown, abdomen rufous with a black oblique line and pale golden spot on each side of segments 2-5 or 6: hairs and bristles of coxæ partly or wholly black (New England to Iowa south to North Carolina and Kentucky) (17-29 mm.) ..... *umbrinus* Loew  
More slender species, thorax brown with 2 darker closely approximate median lines, abdomen with white pruinose lateral spots, long and slender, mostly black in male, more or less reddish-yellow and blackish in female; hairs and bristles of coxæ pale ..... 11
11. Southern Connecticut, west to Missouri and south to the Carolinas (16-28 mm.) ..... *discolor* Loew  
Cuba (not recorded since originally described) ..... *bilineatus* Loew
12. Wings dark (blackish or yellowish-brown) ..... 13  
Wings light, subhyaline, sometimes with apex and anal border lightly clouded ..... 15
13. Hypopleural bristles black; wings broad and quite dark colored ..... 14  
Hypopleural bristles pale; wings narrower and light yellowish; slender pale reddish species, thorax pale brownish pollinose without definite markings, only light reddish wavy or intersected streaks on the mesonotum; abdomen slender, pale reddish, the genitalia dark brown with reddish and black hairs intermingled (Oklahoma) (24-25 mm.) ..... *pritchardi* n. sp.
14. Wings blackish, broad; slender species, yellowish abdomen; thorax light brownish with 2 narrow curved lines medianly, 2 broader lateral vittæ and small spots between lines (Mexico, Arizona, Texas, New Mexico) (19-22 mm.) ..... *sallei* Bellardi  
Wings yellowish-fuscous; abdomen robust, brick-red; thorax brownish with markings similar to *sallei*; a large robust species, (Mexico) (30 mm.) ..... *bigoti* Bellardi
15. Palpi black; abdomen slender, cylindrical, almost wholly yellow with only inconspicuous black spots at sides; wings lightly fumose at apex and anal border: (the thoracic stripes in some specimens quite dark) (southwestern species) (15-17 mm.) ..... A and B  
A. Pile of abdomen chiefly white ..... *perplexus* Back  
B. Pile of abdomen chiefly black ..... *coloradensis* James  
Palpi yellowish or reddish ..... 16

16. Abdomen with black bands above (more or less interrupted) (south-eastern species) ..... 17  
 Abdomen reddish or yellowish, sometimes with darker cloudings above but never with decidedly black bands (species from west of Mississippi river) ..... 18
17. Mesonotum with three dark stripes (sometimes almost black), the median stripe divided longitudinally by a thin line, the lateral stripes divided transversely (17-22 mm.) ..... *salutans* n. sp.  
 Mesonotum without distinct maculations except two thin closely approximate median dark lines: a large, robust species (24-42 mm.) ..... *crudelis* n. sp.
18. Abdomen uniformly pale reddish-yellow, rather short and stout, small species (Arizona and California) (15-21 mm.) ..... *contortus* n. sp.  
 Abdomen with oblique black lines at sides of several segments ..... 19
19. Abdomen elongate and slender; fragile, delicate species (Rio Grande Valley, Texas) (19-23 mm.) ..... *fragilis* n. sp.  
 Abdomen robust ..... 20
20. Abdomen with yellowish or whitish sheen (hairs of ♂ genitalia all pale) ..... 21  
 Abdomen without conspicuous sheen (hairs of ♂ genitalia pale or dark) ..... 22
21. Wings hyaline; abdomen except last 3 or 4 tergites in ♀ with pale yellowish or whitish bloom or sheen; thorax pale golden or whitish pollinose; very large, robust, pale reddish species (Arid regions of west, Colorado to Nevada and Oregon, California and Arizona) (20-38 mm.) ..... *grossus* n. sp.  
 Wings lightly tinged with brown, narrower than the preceding; thorax larger in proportion to length and abdomen broader at base and tapering more sharply to tip; a golden-brown pollinose species with dark bands over dorsum of abdomen, coloration generally darker than *grossus* (California and Arizona) (26-30 mm.) ..... *pulcher* Back
22. Pale brownish-yellow, rather robust species; wings narrow, hyaline; thoracic dorsum olivaceous; abdomen quite stout, rather wide at base and usually with olivaceous or brownish bands above; male genitalia with a number of black hairs; terminal segments of female abdomen rather broad, making the abdomen appear stout and shorter than in the following (Texas and Louisiana, north to the Dakotas) (17-27 mm.) ..... *angustipennis* Loew  
 Reddish-yellow, larger but comparatively less robust species; wings usually broader hyaline; abdomen longer and less robust; male genitalia with mostly reddish hairs; terminal segments of the female abdomen more slender than in the foregoing (Texas and Louisiana, north to the Dakotas) (18-32 mm.) ..... *symmachus* Loew

#### **Diognites esuriens new species**

Total length, 19-24 mm. A pale reddish-yellow species, the mesonotum pale golden pollinose with three velvety-black stripes, the median stripe

divided longitudinally by a thin pale line. The abdomen is slender, pale reddish-yellow without dark cloudings or bands over the dorsum, and is slightly coarctate, the constriction coming between the 2nd and 3rd segments. This species is closely related to *neoternatus* and *misellus* and is frequently to be found labelled in collections as *bilineata* or *ternata*.

MALE. Pale reddish-yellow. Head pale golden pruinose. Proboscis black. Antennæ and palpi pale orange. Mystax, beard and hairs of first antennal segment pale straw-colored; palpal hairs and occipital bristles slightly darker yellowish. Ocellars (2) and hairs and bristles of second antennal segment black. Thorax light golden pollinose (the pleura lighter), the mesonotum with three velvety-black contrasting longitudinal stripes, the median bisected its full length by a pale line, the median vittæ bisected transversely. Vertex of head and humeral region more orange than elsewhere on head or thorax. Hairs of prothorax, pleura and coxæ pale yellow; hairs and bristles of mesonotum and hypopleura (in front of halteres) black. The 2 scutellars are black. Legs pale reddish-yellow with fine scattered black hairs and bristles. Wings grayish subhyaline. Halteres yellowish. Abdomen slender, with a slight constriction between the second and third segments, light reddish-yellow, the sides and posterior borders narrowly, pale golden pruinose; a small velvety-black line on the sides of segments 2-6. Genitalia with black and yellow hairs intermingled. The fine, scattered hairs on the dorsum of the abdomen are black, the bristles at the sides of the first segment pale reddish yellow.

FEMALE. Similar, abdomen slightly stouter and even less coarctate. In the holotype and allotype there are two dark spots on the anterior portion of the 2nd abdominal segment, but these are lacking in the male paratopotype.

Holotype, male, Orlando, Fla., V. 13.3. Allotype, female, Agr. Exp. Sta., Gainesville, Fla. (no. E L 355) (J. R. W.). Paratopotype, male, Orlando, Fla., July 23, 1924 (O. C. McBride). Paratypes, males, McBee, South Carolina, Sept. 7-11, 1931 (S. W. Bromley); females, La Grange, Brevard Co., Fla., Sept., 1913 (Wm. T. Davis), Lake Worth, Fla. (two), November 6, 1928 (S. W. Bromley) [In S. W. Bromley collection]; 1 female, Miami, Fla., April 11-21, '23 (F4666C) [Am. Mus. Nat. Hist.]; Alachua Co., Gainesville, Fla., 5 males, 9 females, May 16-Nov. 25 (Coll. T. H. Hubbell, F. W. Walker, J. W. Johnson); Wayne Co., Jesup, Ga., Aug. 30, 1923 (T. H. Hubbell) [Univ. of Mich. Coll.]; Branford, Fla., July 31, 1930 (R. H. Beamer, J. Nottingham, P. W. Oman, L. D. Tuthill), Loughman, Fla. (one female with a large yellow-antennæ *Ceropaltes* (?) spider wasp as prey), Aug. 2-5, 1930 (R. H. Beamer, J. Nottingham, L. D. Tuthill), Fruitville, Fla., Aug. 11, 1930 (R. H. Beamer, J. Nottingham,

L. D. Tuthill), Waldo, Fla., Aug. 18, 1930 (J. Nottingham), Hilliard, Fla., Aug. 19, 1930 (Paul W. Oman), Lacoochie, Fla., Aug. 18, 1930 (J. Nottingham) [Univ. of Kansas Coll.].

**Diognites properans** new species

Total length, 17-22 mm. A rather small, reddish-yellow species with three black contrasting stripes on the mesonotum, the median stripe exceptionally broad, not divided by a yellow line, and the abdomen with blackish bands over the dorsum of the segments. These bands are frequently more or less interrupted. Related to *D. salutans* n. sp. from which it may be distinguished by the presence of contrasting black stripes of the mesonotum, instead of brownish stripes not contrasting, the median of which is divided. This is one of the species frequently labelled as *rufescens* in collections.

MALE. Reddish-yellow, head golden pruinose. Proboscis black, bulb reddish. Palpi and antennæ pale reddish, 3rd segment of antennæ blackish above. Mystax, beard and hairs of first antennal segment pale straw-colored; palpal hairs and occipital bristles slightly darker yellowish. Ocellars (2), hairs and bristles of second antennal segment black. Thorax pale golden pollinose, the mesonotum with three black velvety bands, the median very broad and dark (Under lens it is seen to be bisected very narrowly by a thin dark reddish line), the lateral vittæ divided transversely by a golden line. Fine hairs of pleura, prothorax, and coxæ pale yellow; pronotal and hypopleural bristles reddish. Hairs and bristles of mesonotum black as are the 2 (or 3) scutellars. A black mark on the pleura at the junction of the 2nd and 3rd coxæ. Legs pale reddish-yellow. Halteres dark brown. Wings grayish subhyaline. Abdomen rather short and stout, reddish-yellow, the posterior margins and lateral angles of the segments pale yellow pollinose, each segment with a black band over the dorsum usually fading to brownish or reddish toward the median area, but in some specimens entire. Hairs of genitalia largely black but with a few reddish hairs intermingled.

FEMALE. Similar.

Holotype. Male, Theodore, Ala., June 12, 1917 (R. C. Shannon). Allotype, female, Pass Christian, Harrison Co., Miss., June 14, 1917. Paratopotypes, males (3), females (2). Paratype, female, Mobile, Ala., June 12, 1917 [S. W. Bromley and Cornell Univ. Coll.]; 1 male, 2 females, Gainesville, Fla., Sept. 26-Oct. 2, 1914 [Am. Mus. Nat. Hist. Col.]; Leesburg, Lee Co., Ga., Aug. 19, 1932 (L. N. Gloyd), Everett City, Glynn Co., Ga., June 22, 1930 (C. F. Byers) [Univ. of Michigan Coll.]; Prattsburg, Ga., July 25, 1930 (P. W. Oman and L. D. Tuthill), Tuskegee, Ala., July 22, 1930, one, a female, with small *Bombus* sp. as prey, (R. H. Beamer), Waldo, Fla., Aug. 18, 1930 (R. H.



Beamer), Hilliard, Fla., Aug. 19, 1930 (R. H. Beamer), Coatopa, Ala., July 18, 1930 (R. H. Beamer), Suwanee Springs, July 29, 1930 (R. H. Beamer) [Univ. of Kan. Coll.].

***Diogmites crudelis* new species**

Total length, 24–33 mm. A large, robust, light reddish species, the mesonotum light brown with two dark closely approximate median lines. The abdomen with dark brown or blackish bands over the dorsum. This species was identified by Back and others as *rufescens*, while exceptionally large individuals from Florida were called *bigoti*.

MALE. Reddish-yellow, head pale yellow pruinose. Proboscis black; bulb, palpi and antennæ reddish-orange. Vestiture of head pale yellow or whitish, except ocellar bristles (4) and hairs and bristles of 2nd antennal segment which are black. Thorax pale reddish-brown, yellow pollinose, the mesonotum with two thin dark-brown or blackish, closely approximate median lines. Mesonotal hairs and bristles black. Scutellars, two, black. Pleura, prothorax and coxæ with pale yellow hairs. Hypopleural and pronotal bristles reddish-yellow. Halteres pale brown. Wings brownish subhyaline. Legs pale brownish-yellow. Abdomen reddish with the extreme posterior margins of the segments and lateral angles yellowish pollinose. The dorsum with blackish bands fading into reddish-brown toward the median line in some specimens, complete in others. Genitalia reddish with mostly reddish hairs, a few black intermingled.

FEMALE. Similar.

Holotype, male, Wilmington, N. C., July 14, 1925 (T. B. Mitchell). Allotype, female, McBee, S. C., Aug. 29, 1930 (S. W. Bromley). Paratypes, 5 females, McBee, S. C., Aug. 29–Sept. 2, 1930 (one of these with a large reddish spider wasp, *Arachnophroctonus ferrugineus* Say as prey); Southern Pines, N. C., Sept. 1906 (R. S. Woglum); Pablo Beach, Fla., Sept. 5, (Wm. T. Davis) [in S. W. Bromley Coll.]; Hilliard, Fla., Aug. 19, 1930 (R. H. Beamer), Childs, Fla., Aug. 6, 1930 (two gigantic specimens, 42 mm. in length, with the dark lines on mesonotum almost obsolete) (P. W. Oman) [Univ. Kan. Coll.].

***Diogmites salutans* new species**

Total length, 17–22 mm. A pale brownish-red species with the thoracic stripes brownish, the median of which is narrowly bisected longitudinally by a thin line and the lateral spots divided transversely. The abdomen is robust, reddish with blackish bands extending over the dorsum. These bands are more or less interrupted at the median dorsal line. This species is closely related to *properans* n. sp. and *crudelis* n. sp., all of which in the past have

been erroneously identified as *rufescens*. The present species has been labelled *bilineata* and *symmachus* in collections, also.

MALE. Head golden pollinose. Third antennal segment orange-brown, second with black bristles. Ocellars (4, in some of the specimens only two) black, rest of vestiture of head pale yellow. Proboscis black, palpi brownish. Mystacial bristles almost white. Thorax golden brown pollinose, legs pale brownish yellow. Pronotal bristles pale brownish, sometimes with a few darker bristles intermingled. Hypopleural bristles reddish-yellow. Fine hairs of prothorax, pleura, and coxæ pale yellow. Hairs and bristles of mesonotum black. Scutellars (2) black. Disc of mesonotum with three dark brown stripes, the median distinctly bisected its whole length, the lateral vittæ divided transversely. Wings gray subhyaline. Halteres dark brown. Abdomen stout, reddish, the posterior margins and lateral angles of the segments yellow pollinose, each segment with a broad black band above. These bands may fade into brown or reddish at the middle but become black again on the sides. In other instances, the bands are entire. Genitalia reddish with mostly black hairs, some reddish intermingled.

FEMALE. Similar.

Holotype, male, Elrod, N. C., Sept. 13, 1925 (S. W. Bromley). Allotopotype, female, (S. W. B.). Paratypes; one male, seven females from Jekyll Island, Ga., Sept. 18–19, 1925 (two of the latter with small bumblebees, one with a winged ant, one with a *Tiphia* sp., and one with a female of the same species as prey) (S. W. B.), female, Smithfield, Va., female, Ridgeland, S. C., Aug. 13, 1926 (F. Sherman), female, Meredith, S. C., Aug. 27, 1925 (O. Cartwright), male, Keysville, Burke Co., Ga., June 28, 1930 (C. F. Byers) [in S. W. Bromley Coll.]; female, Sandfly, Savannah, Ga., July 3–14, 1916 (Ac 4849), female, Deen Wood, Waycross, Ga., July 16–18, 1916 (Ac 4849), male, Homestead, Fla., April 18, 1923 (F4673) [Am. Mus. Nat. Hist. Coll.]; two males, four females, Alachua Co., Fla., May 20–July 24, (Alexander, Walker, and Everts), Fort Lauderdale, Fla., July–Aug. 19 (D. M. Bates), female, Rock Bluff Landing, Liberty Co., Fla., July 29, 1925 (T. H. Hubbell), female, Newberry Co., S. C., June 30, 1930 (C. F. Byers) [Univ. Mich. Coll.]; 22 specimens from the following, Lacoochie, Fla., Aug. 18, 1930 (J. Nottingham and R. H. Beamer), Plant City, Fla., Aug. 15, 1930 (R. H. Beamer), Deerfield, Fla., Aug. 6, 1930 (R. H. Beamer and J. Nottingham), Waldo, Fla., Aug. 18, 1930 (R. H. Beamer and L. D. Tuthill) (a female with small dragon-fly *Sympetrum* ?, as prey) Hilliard, Fla., Aug. 19, 1930 (L. D. Tuthill and P. W. Oman), Fruitville, Fla., Aug. 11,

1930 (L. D. Tuthill), Shuquaiak, Miss., July 16, 1930 (R. H. Beamer), Tuskegee, Ala., July 27, 1930 (R. H. Beamer), Prattsburg, Ga., July 25, 1930 (P. W. Oman) [Univ. Kan. Coll.]

This species may eventually prove to be only a variety of *D. properans*.

***Diogmites contortus* new species**

Total length, 15–21 mm. A small, pale yellowish species from the southwest, the abdomen short and stout without black markings. The mesonotum is pale yellowish-brown with three pale longitudinal markings, only slightly darker than the rest of the mesonotum.

MALE. Head pale yellow pollinose. Palpi, antennæ and bulb of proboscis pale reddish-yellow. Rest of proboscis black. All bristles and hairs of head and antennæ yellowish (mystax very pale) except the two ocellars which in the holotype are yellow, but in the others dark reddish to brownish. Thorax pale yellow pollinose, all hairs and bristles of prothorax, pleura (including hypopleural bristles) and coxæ pale yellow. Hairs and bristles of mesonotum black. Scutellars (2) black. Disc with three pale brownish-yellow broad lines over which the pollen of the thorax does not extend. Wings, short, gray subhyaline. Halteres pale brownish-yellow. Legs pale brownish-yellow. Abdomen short and stout, pale reddish-yellow without black markings, simply a faint brown oblique line barely visible at the sides of the segments of some specimens. Genitalia with pale reddish hairs.

FEMALE. Similar.

Holotype, male, Yuma, Arizona, June 23, 1925 (S. W. Bromley). Allotopotype, female, same date (S. W. B.). Paratopotypes, a male and a female, same date (S. W. B.) [in S. W. Bromley Coll.]. Paratypes, 4 females, Blythe, Calif., Aug. 20, 1927 (Lot 542 sub 327) [Cornell Univ. Coll.].

In the field this species has a pronounced golden yellow appearance as it flies about near the ground with a thin high-pitched buzz. The males and possibly the females were observed to carry the abdomen doubled under the thorax during flight, giving the fly the appearance of a more robust asilid such as *Mallophora*.

***Diogmites fragilis* new species**

Total length, 19–23 mm. A reddish, very slender species from the lower Rio Grande valley of Texas, with narrow wings and elongate, slender abdomen, the genitalia bulbous and considerably wider than the seventh segment. The pleura and sides of the abdomen are whitish pruinose and pollinose. The hairs of the genitalia are largely black. Related to *angustipennis*, from which it may be distinguished by its more slender build and slender, elongate abdomen.

MALE. Head very pale yellow pollinose. Mystax pale straw-colored. Antennæ reddish, palpi brown, proboscis black. Beard white. Occipital bristles and palpal hairs sordid yellowish. Thorax pale reddish brown, pleura silvery gray pollinose. Hypopleural bristles very fine, yellowish, other hairs of pleura and coxæ sordid whitish. Mesonotum with broad reddish brown stripes, the hairs and bristles black. Scutellars (2) black. Wings narrow, subhyaline, grayish toward apex. Halteres brown. Legs long, slender, reddish brown. Abdomen elongate, slender, reddish-brown, the sides and borders of the segments whitish pollinose. A blackish, oblique line at the side of each segment. Genitalia dark brown with dark brown and black hairs, bulbous, wider than seventh segment.

FEMALE. Similar, but with wings less hyaline.

Holotype, male, Donna, Texas, Sept. 3, 1933 (J. W. Monk). Allotype, female, Kingsville, Texas, Oct. 19, 1935 (G. M. Kohls), [in C. B. Philip Coll.]. Paratopotype, male, same date as holotype (J. W. Monk), [in S. W. Bromley Coll.].

#### **Diogmites grossus** new species

Total length, 28-38 mm. A very large, robust species of the arid west, reddish-yellow with a whitish or pale yellowish bloom or sheen, the wings hyaline. Closely related to *symmachus*, from which it may be distinguished by the larger size and the whitish sheen of the abdomen and thorax. This species is usually found in collections labelled *bigoti*.

MALE. Head yellowish white pollinose. Mystax and beard pale yellowish-white. Palpi and antennæ pale orange-brown. Ocellars (2), occipital bristles and palpal hairs pale sordid yellow. Thorax pale reddish-brown covered with a pale whitish or yellowish sheen, the three mesonotal stripes showing through as darker. Hairs and bristles of prothorax, pleura and coxæ whitish. Hypopleural and pronotal bristles pale yellow. Mesonotal bristles and scutellars (2) black. Some of the fine bristles on the posterior median part of mesonotum yellow. Legs pale reddish. Wings long, hyaline. Halteres pale brownish. Abdomen long, robust, pale reddish covered thinly with a whitish sheen. A faint dark oblique line discernible on the sides of the segments of some of the specimens. Genitalia pale brownish with light hairs.

FEMALE. Similar. Last three or four tergites without the whitish sheen. The paratype from Utah is paler than the Colorado specimens and the ground color lighter reddish-yellow.

Holotype, male, Lamar, Prower Co., Col., Aug. 25, 1925 (F. M. Gaige). Allotopotype, female, same data. Paratype, female, near Midvale, Utah, July 26, 1913 (Timberlake), female, Grand Co., Moab, Utah, Sept. 2, 1929 (L. K. Gloyd) [in S. W. Bromley Coll.]; female, White Rock, near Boulder, Col., Aug. 13, 1919



(F4410), female, Wray, Col., Aug. 17-19, 1919 (F4411D) [Am. Mus. Nat. Hist. Coll.]; 3 males, 3 females, Lamar, Prower Co., Col., Aug. 25-27, 1925 (F. M. Gaige), 2 females, Zion Nat'l. Park, Kane Co., Utah, Aug. 20, 1932 (C. J. D. Brown), female, Moab, Grand Co., Utah, Aug. 17, 1929 (L. K. Gloyd), female, Lemoore, Calif., Sept. 22, 1922 (L. R. Dice) [Univ. Mich. Coll.]; 19 specimens, Parma, Idaho, Aug. 4-19, 1934 (C. H. and Dorothy Martin) (a male in this series dated Aug. 19, 1934, with a honey-bee as prey) [J. Wilcox Coll.]. Male, with worker *Vespa occidentalis* as prey, Phoenix, Ariz. 1929 [Col. State College Coll.].

***Diogmites pritchardi* new species**

Total length, 24-25 mm. A pale reddish species related to *D. sallei*, from which it may be distinguished by the pale hypopleural bristles and the narrower and paler wings. The thoracic markings are somewhat similar but are paler and indefinite consisting of two pale reddish closely approximate median lines, separated by a pale pollinose line which is bisected by a median row of brownish dots; the lateral vittæ are bisected transversely; and between the median lines and lateral vittæ there is on each side a wavy row of brownish dots.

MALE. Head whitish pollinose, vertex and occiput showing the pale reddish ground color. Beard and mystax white. Proboscis black. Antennæ and palpi orange with dark orange hairs and bristles. Thorax pale reddish, whitish pollinose on pleura and coxæ. Hairs and bristles of sides pale; supra-alars and scutellars black. Thorax whitish pollinose above, the mesonotum with markings described above. Hypopleural bristles pale. Wings yellowish, pale brownish toward tip and along posterior border. Halteres pale reddish. Abdomen long, slender, pale reddish. Genitalia blackish-brown with blackish and reddish bristles intermingled. Legs pale reddish with black bristles.

FEMALE. Similar.

Holotype, male, Alfalfa Co., Okla., Aug. 9, 1932 (A. E. Pritchard). Allotopotype, female, same data. [In S. W. Bromley Coll.]. Paratype, Aransas Co., Texas, Aug. 6, 1928 (Jack Beamer). [Univ. Kansas Coll.].



## THE CIRPHIS PSEUDARGYRIA COMPLEX (LEPIDOPTERA: NOCTUIDÆ)

By WM. T. M. FORBES

CORNELL UNIVERSITY, ITHACA, NEW YORK

*Cirphis pseudargyria* has always been considered a well defined and well isolated species, with no close relatives in America save the rare Floridian *C. pilipalpis* Grote. Examination of the male structures shows that there are four species, strikingly different in male antenna, palpi, leg tuftings and genitalia, but practically identical in markings. I am convinced that the true *pseudargyria* Guenée\* is the one figured by J. B. Smith (Proc. U. S. Nat. Mus. xxv, pl. v, fig. 2, genitalia), Hampson (Cat. Lep. Phal. v, 481, fig. 147) and Holland (Moth Book pl. xxiv, fig. 47). This is the only one that has the red tinted markings, shared by the European *C. lithargyrea* with which Guenée compares it, and this is the species that has a red form (*callida* Grote) so similar in tint to *C. obusta* Guenée (Hampson pl. xci, fig. 17) that Smith might easily have called them identical in a memory comparison (U. S. Nat. Mus. Bull. 44, p. 190). It also has a form in which the darker markings are more or less shaded and frosted with very dull red (typical) and one with the red practically wholly replaced by gray (corresponding to *lithargyrea*, ab. A of Guenée, ab. 1 of Hampson, *derufata* Strand).

These three species are so nearly identical that as a whole Hampson's description will serve for all three, save that for form *derufata* of *pseudargyria*, and the other three species the words implying reddish tints should be replaced by "gray"; and except for the few points in the following comparative descriptions.

\* Since this was written Mr. J. W. Cadbury, 3rd, has kindly compared the material in the British Museum. Guenée's type of *pseudargyria* is this species. The material now standing as *derufata* Strand is a mixture of *ursula* and *inermis*, but there is no certainty that Hampson's "Ab. 1" was entirely based on them, since he did not specially label the specimens of his unnamed aberrations, and they were partly based on material in other collections, remarks in the literature, and perhaps even on specimens since discarded.

*Cirphis pseudargyria* Guenée

1852. *Leucania pseudargyria* Guenée, Hist Nat. Ins. Lep. (Het.) v, 74.  
 1893. *Leucania pseudargyria* Smith, U. S. Nat. Mus. Bull. xliv, 189 (bibliography, except ref. to *obusta* Guenée).  
 1902. *Leucania pseudargyria* Smith, U. S. Nat. Mus., Proc. xxv, 178, in part, pl. v, fig. 2 (♂ valve).  
 1903. *Heliophila pseudargyria* Holland, Moth Book, 201, pl. xxiv, fig. 47 ♀.  
 1905. *Cirphis pseudargyria* Hampson, Cat. Lep. Phal., v, 481, fig. 147 (except note "The single gray male from Canada.")

Variety *callida* Grote

1882. *L. p.* var. *callida* Grote New List 30, note.  
 1893. *L. p.* var. *obusta* Smith, l. c.  
 1902. *L. p.* var. *callida* Smith, l. c.

Variety *derufata* Strand\*

1905. *C. p.* Ab. 1, Hampson, l. c.  
 1916. *Cirphis pseudargyria*, ab. *derufata* Strand, Archiv für Naturg. A 1916 (2) 30.  
 1925. *Cirphis pseudargyria* form *callida* Draudt, Seitz Macrolep. World, xi, 163 (in error).

Darker markings of *fore wing* shading from very dull red (fawn color, 13''' of Ridgway, to army brown, 13i''' of Ridgway) to a pure gray (var. *derufata* Strd.), rarely wholly of the army brown except for the pale lower half of the reniform (*callida* Grt.).

*Discal lunule* of under side of hind wing, usually absent.

*Male front* fuscous, shading into dull red above.

*Palpi* blackish, contrasting, very high in proportion, shaggy.

*Pectus* heavily shaded with the dull red, and some gray.

\* Strand's description has nothing tangible, and could apply equally to any one of the three species; presumably there is no type, and the type locality is merely "North America." To judge by his usual custom it is probably based on the general statements in the literature and Hampson's in particular that *pseudargyria* has a gray phase. My assumption that it represents the gray form of true *pseudargyria* is arbitrary, but the alternative would be to treat it as a hopelessly ambiguous "nomen inquirendum."



*Male antenna:* Lower posterior row of setæ abruptly much enlarged, beginning about the 15th segment, occasionally the first long one separated by a segment or two from the next. Upper posterior row beginning to be long similarly at about segment 20; anterior rows at the terminal brush only; setæ about 3 times as long as width of segments; terminal brush of 25 or 30 extremely small and short segments, with very long setæ on all four rows.

*Fore tibia* with massive triangular tuft, its hairs toward base erected almost perpendicularly and much longer than length of tibia; blackish, with the outer part paler and reddish; *metatarsus* with triangular tuft continuing the tibial tuft, (misfigured by Hampson.)

*Mid tibia* with massive outer tuft, but only rough hair on metatarsus.

*Hind tibia* moderately tufted, much smaller than fore and middle tibiæ.

*Preanal tuft* (retractile, on eighth segment) massive.

*Male genitalia* (fig. 1): *Uncus* with slender stem and circular terminal disc about  $\frac{1}{3}$  its length, heavily spined all around the under side (seen obliquely in the figure).

*Valve:* *Terminal lobe* bluntly rounded.

*Hairy pad* at base broad, about half as long as width of terminal lobe.

*Clasper* with spines at upper and lower outer angles, moderate in width; the lower outer spine just reaching the edge of the recess in the valve which contains it; *terminal spine* slender, as long as width of clasper.

*Juxta* moderately chitinized, vaguely emarginate at tip.

*Penis* with large spine slenderer than in *C. inermis*; small spines well developed, the more basal ones fused into a multidentate plate.

*Female.* Generally distinguishable by its large size (full 40 mm.), reddish tint, almost always more or less visible on front and pectus if not on wing, and very weak or absent discal lunule on under side of hind wing. Tibiæ a little more hairy than in *C. inermis* ♀, almost as hairy as its male. The female is not noticeably smaller than the male, and Smith's statement to that effect is probably due to his mistaking specimens of *inermis* for females

of this. Ithaca dates indicate a single brood in mid-July, flying a little later (Aug.) at McLean, and at Orono, Me.

***Cirphis ursula* new species**

1905. (Larva only) *Cirphis pseudargyria* Dyar in Hampson, Cat. Lep. Phal. v, 481.

*Average expanse* of summer brood 30 mm., spring brood larger, but rarely reaching 40 mm.

*Fore wing* without any trace of reddish tint in the dark markings, which are otherwise identical with *C. pseudargyria*; terminal half of fringe often (perhaps always when fresh) pinkish-glossed.

*Discal lunule* of under side of hind wing distinct.

*Male front* fuscous across middle, without reddish tint, contrasting light clay color below.

*Male palpi* much broadened below with close-set short small luteous scales, which tend to make a sharp ridge on inner ventral side; wider than high; upper part of sides more or less fuscous.

*Pectus* solidly blackish, making a conspicuous dark patch with the fore leg tuftings, contrasting with palpi.

*Male antenna*: Lower posterior row of setæ commencing to be enlarged about the 15th segment but very gradually; upper posterior row similarly gradually enlarged at about the middle of the antenna (near segment 30); anterior rows not much lengthened even on the terminal brush; setæ about twice as long as thickness of shaft; terminal brush less specialized, the segments longer and the setæ only about 4 time as long as their width.

*Fore tibia* with outer tuft even longer than in *C. pseudargyria*, nearly twice as long as tibia, when perfect sheared off evenly in an arc whose center is at the knee; also with a shorter massive truncate tuft on inner side of knee; *metatarsus* with a small triangular tuft, well set off from the tibial one; the hairs of the outer tibial tuft becoming blackish toward their tips.

*Mid tibia* with a massive but shapeless paler tuft; *metatarsus* with clean-cut triangular tuft.

*Hind tibia* with abundant loose hair on outer side.

*Preanal tuft* about as in *pseudargyria*..

*Male genitalia* (fig. 2): *Uncus* with terminal spoon-shaped expansion, tapering toward base, and gradually reaching the width of its stem at about half its length; spines of under side weaker, on edges of its terminal half.

*Valve*: *Terminal lobe* roundly pointed.

*Hairy pad* much as in *pseudargyria*, rather weaker.

*Clasper* with a rudimentary spine at outer upper angle only, much narrower, nowhere reaching the edge of recess in valve; *terminal spine* extending far beyond its outer edge, stouter than in *pseudargyria*.

*Juxta* heavily chitinized, sharply bifid at tip.

*Penis* with smaller spines rudimentary, apparently without fused spines.

Ithaca, New York, late May to early June (large specimens); August; late Sept. to Nov. 1; (holotype and many paratypes);

Kinderhook and Orient, L. I., N. Y., the latter collected by Latham; Pleasant Valley, Conn. (? coll. Pasch, without label); Arendtsville, Pa. (Frost); Alexandria, Va., May 27, '17 (Bradley), the two latter records based on single females. The species evidently has two broods and a partial third, late specimens being relatively rare, and midsummer ones sometimes abundant. Cornell University, type No. 1393.

There are also the following paratypes in the U. S. National Museum, besides a few females from other localities not safely determined: Newton Highlands and Chicopee, Mass., Long Id., N. Y. (spring specimens only, one determined as *callida* in Neumoegen collection\*), Lakehurst, N. J. (♀ only), Washington, D. C., Cape Henry, Va., Tryon, N. Y. (♀ only), New Brighton, Pa. (♀ only), Decatur, Ill. (spring form only), and Iowa City, Ia. A single female from Glenwood Springs, Colo., April, is likely to belong here also.

*Female.* Summer and fall specimens distinguishable by their small size; spring ones not certainly separable from *C. inermis*. None show the reddish tints of front, pectus and wings of *C. pseudargyria*, and the discal lunule is always distinct, often large. I am inclined to believe the tibiae are more hairy than those of *C. inermis*, but have not enough perfect material to be sure.

I am able to examine the larva described by Dyar and its associated moth through the courtesy of Mr. Benjamin. The moth is a female but seems safely this species rather than *inermis*. Caterpillar cream, reticulate with brown. Head shining, front with a vague vertical brown bar only, adf. immaculate; epicrania coarsely reticulate, with the pattern flowing together into two vertical brown stripes down the front of the epicrania, diverging

\* Mr. Benjamin would consider this determination authentic. I cannot believe that a form whose only description is the single word "red" can be truly represented by a specimen that is grayer than the great majority of the specimens of this complex. The U. S. National Museum, to be sure, has a striking lack of the reddish specimens, but this is true of no other collection I have seen, and I suspect some secondary disturbance. Even on a memory comparison I do not believe that Smith could mistake the solid reddish *obusta* (Hampson, Cat. Lep. Phal. v, pl. 91, fig. 17) for this gray species, especially as his figure of the genitalia shows he had a correct conception of *pseudargyria*.

below, and running closely parallel to adfrontals. Body with dorsum a little darker, especially at edges, and a darker suprastigmatal band. Fine pale lines, all defined with slender darker shades; dorsal, subdorsal (below ii), lateral (above iii) and stigmatal, and faint stripes subventrally. Ventral leg plates shining brown; the prothorax and anal leg-plates dark, but mottled and not shining. Spiracles black. The specimen is an inflation, and may have been more grayish or greenish in life.

***Cirphis inermis* new species**

*Average expanse* 35 mm.

*Fore wing* without any reddish tint, the markings frequently absolutely identical with the preceding, but more often with the dark subterminal shade opposite the cell a little stronger. Pink iridescence practically wanting, but just traceable in a favorable light.

*Discal lunule* well marked.

*Male front* light (clay color) except at sides, which are blackish, with a little reddish tint.

*Palpi* higher than wide, the scaling as smooth as in the preceding, but not as fine, much like females of all three species; shaded in varying proportions of blackish and luteous, usually with the boundary indefinite.

*Pectus* nearly concolorous, not conspicuously either reddish or blackish.

*Male antenna* unmodified, the four rows of setæ all similar, short, and terminal segments not specialized.

*Fore tibia* with tuft small, its hairs much shorter than length of tibia, the *metatarsus* without a special tuft.

*Mid and hind tibiæ* similar.

*Male genitalia* (fig. 3): *Uncus* spatulate, long, abruptly narrowing near the point of attachment only; the spines on under side weak and only along its apical third.

*Valve*: *Terminal lobe* as in *pseudargyria*.

*Hairy pad* long and narrow, covering the whole joint between terminal lobe and body of valve.

*Clasper* enormously widened on upper half, extending over the edge of the recess; *terminal spine* massive, but much shorter, the outer angles rounded over without trace of spines.

*Juxta* shapeless, not bifid.

*Penis* with largest spine massive, small spines as in *pseudargyria*.

*Female* practically identical with the preceding; the tibiæ with very little loose hair.

Ithaca, N. Y., end of May to early July, not rare in 1919 and 1922. Females from Peru, July 4, and Rock City, June 11 (Fbs.), and Greenpoint, (L. I.), N. Y., Aug. 1 (Latham), also



from Fredericksburg, Va., May 30 (Bradley) appear to belong to this species. Hampson reports this species (cf. by Cadbury) from Canada ("The single gray male," under *pseudargyria*). Ithaca dates indicate a single brood, with the climax in June, but the August female from L. I. if correctly associated, indicates a second brood there. The United States National Museum has paratypes from Center (Karner) and Forest Park (L. I.), N. Y., besides a couple of doubtful females.

***Cirphis calidior* new species**

*Expanse* 38 mm.

*Fore wing* without reddish tint, but more buffy than the other species, the oblique blackish dash to apex almost sharp, and conspicuous; discal dot conspicuous, much stronger than in *pseudargyria*, though matched by some specimens of the other species.

*Discal lunule* of hind wing below, strong.

*Male front* clay color, with small blackish patches at sides only.

*Palpi* not modified; mostly clay color, the inner face contrastingly dark.

*Pectus* clay color, dark gray on sides, the hair mixing with the similar dark gray tuft of the fore femur.

*Male antenna* simple.

*Fore tibia* with large triangular tuft, mostly clay color, but the hair from toward base of tibia darker; *femur* with dark hair; *metatarsus* with smaller but similar tuft.

*Mid tibia* with large pale tuft; the *metatarsal* tuft as large as in *C. ursula*, but looser.

*Male genitalia* (fig. 4): *uncus* slender, only a little widened to tip, the bristles not very strong and gradually fading out down the shaft.

*Valve*: *Terminal lobe* subtriangular, with outer edge relatively much shorter than in *C. ursula*; some of its setæ set back from the margin.

*Hairy pad* short and small.

*Clasper* much widened outwardly, but with its lower part more widened than the upper, unlike *C. inermis*, the upper outer angle sharp, and lower angle marked; *terminal spine* diverging more from rest of clasper than in the remaining species.

*Juxta* long, slightly bifid, with slight central keel.

*Penis* with two massive spines; unlike the others, which have one of the spines very slender.

*Female* not seen, perhaps separable by the oblique apical dash.

Clarke County, Georgia, Aug. 12, 1928 (A. G. Richards). Type unique, donated by Dr. Richards to the U. S. National Museum.

*Cirphis pilipalpis* from Florida also belongs to this group. Both sexes can be distinguished by the long cylindrical second segment of the palpus, with a large fanlike tuft near its tip above in the male, and a weak tuft in the female. Tibiæ and fore metatarsus only moderately tufted, but mid metatarsus with a distinct triangular tuft as in *C. ursula*. Antenna with upper posterior setæ abruptly lengthened beginning about the middle of the shaft, lower posterior setæ very gradually lengthening from near base. Postmedial line continuous, scalloped, as in some specimens of *C. inermis*, but more contrasting.

#### PLATE VI

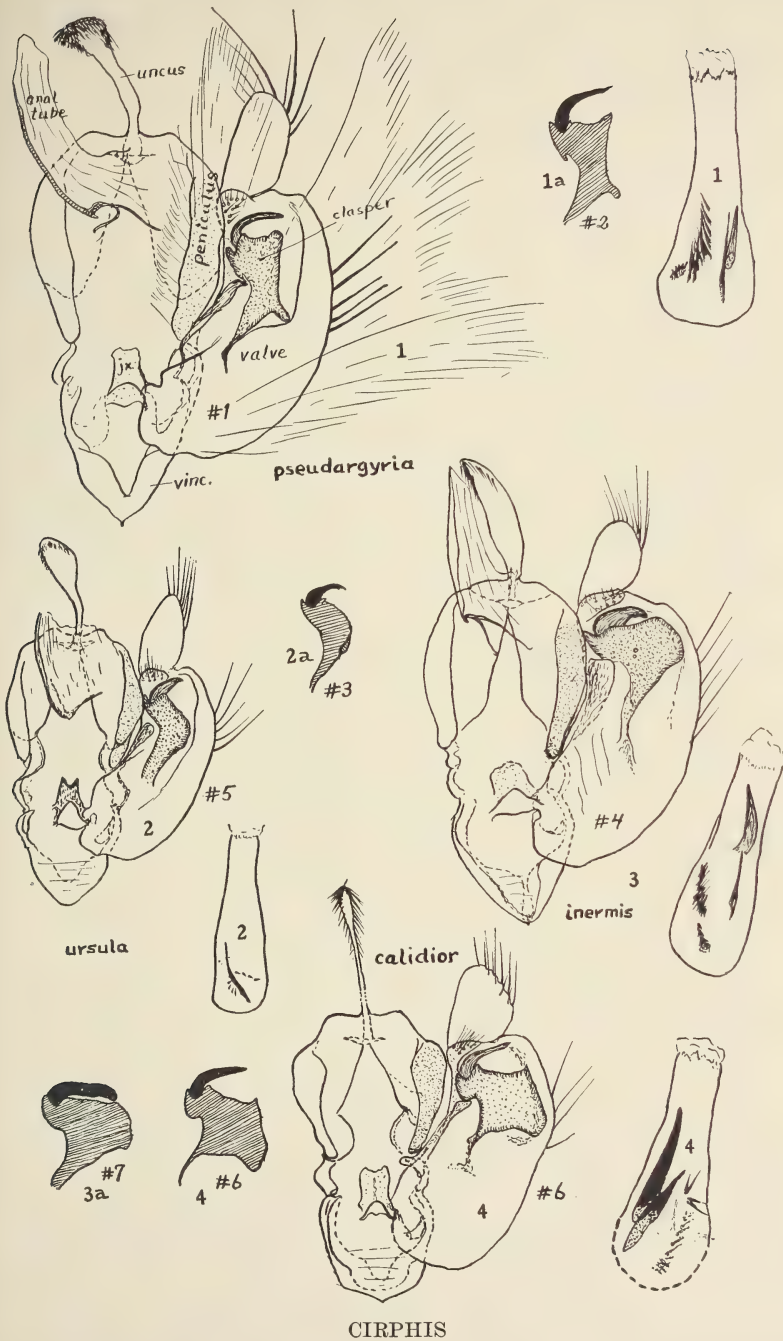
The figures are of the male genitalia, opened from the ventral side, with the left valve removed and the penis drawn separately.

Figure 1. *Cirphis pseudargyria* Guenée; 1a, clasper of another specimen, drawn separately. (jx. is the juxta)

Figure 2. *Cirphis ursula*, new species; 2a, clasper of another specimen.

Figure 3. *Cirphis inermis*, new species; 3a, clasper of another specimen.

Figure 4. *Cirphis calidior*, new species, with clasper also drawn separately.







## BEEES FROM BRITISH GUIANA

BY THEO. D. A. COCKERELL

Owing to increased transportation facilities, it is now comparatively easy for an entomologist living in New York or New England to go on a collecting trip to the West Indies or northern South America. Such an expedition should delight any student of insects, the fauna being so rich in large and beautiful species, many of which have interesting habits. A committee of specialists should be formed to prepare a manual, with illustrations, describing the principal members of this neotropical fauna. It will be found that most of the more conspicuous species were described by the fathers of entomology, such as Drury, Fabricius and Latreille. There are, however thousands of rarer or less conspicuous forms which still await discovery and description, so that even a short visit may be productive of very interesting results.

Mr. and Mrs. J. Ogilvie, who collected so many bees in Africa, are now in British Guiana, and a small consignment received from them includes the following.

(A.) Onverwagt, 54 miles east of Georgetown. December 14-15.

*Xylocopa barbata* (Fabricius). A small carpenter bee with dense pure white hair on cheeks.

*Xylocopa fimbriata* (Fabricius). A large black bee with shining green wings.

*Centris versicolor* (Fabricius).

*Centris obscuriventris* Friese. This seems to be only a variety of the last, as Friese himself supposed.

*Florilegus pavoninus* Cockerell. One female. Described from Ecuador.

*Melipona favosa* Fabricius. Male.

*Halictus guianensis* sp. n.

*Megachile luctifera* Spinola. A beautiful species, with pure white bands on abdomen, and black ventral scopa.

*Megachile laticincta* sp. n.

(B.) Plu Ruimveldt, one mile south of Georgetown. Dec. 19.

*Euglossa cordata* (Linnaeus). A splendid green bee.

*Xylocopa barbata* (Fabricius).

*Xylocopa fimbriata* (Fabricius).

*Melitoma euglossoides* Lepeletier and Serville.

*Megachile rufobarbata* sp. n.

***Megachile laticincta* sp. n.**

Female. Length 13 mm.; robust, with heart-shaped abdomen, the sixth tergite nearly in a straight line with those before, but somewhat ascending at end; black, without metallic tints; mandibles and scape black, flagellum obscurely rufescent beneath; tegulæ ferruginous; wings dusky hyaline, with red stigma and brown nervures, the outer ones dark; ventral scopa long and white, black on last sternite, and black hair along sides; sternites not banded under the scopa. Head broad, but facial quadrangle longer than broad; mandibles broad, quadridentate, the second and third teeth broadly triangular (mandible much as in *M. kartaboensis* Mitchell, but bee quite different); clypeus short and broad, densely punctured at sides, in middle polished between the punctures, with a rather poorly developed smooth band; middle part of margin of clypeus finely denticulate (style of *M. affabilis* Mitchell); sides of face with white hair, not conspicuous; clypeus with very inconspicuous pale hair and some very long dark hairs; front, occiput and cheeks with pale fulvous hair, on vertex it is browner; mesothorax very closely and finely punctured, a little shining on disc posteriorly, and anteriorly with a smooth line; hair of thoracic dorsum in front, at sides (over tegulæ) and on scutellum abundant and rufofulvous, but disc of mesothorax with thin whitish hair, only conspicuous in certain lights; sides of thorax with fulvous hair above, white below; scutellum dull and very finely punctured, with a smooth median line; legs black; hind basitarsi broad, but not quite as broad as tibiæ; front legs with last tarsal joint red; tarsi with rather thin pale hair; first tergite with long fulvous hair; second to fifth with very broad pale yellow bands of tomentum, interrupted in midde; last sternite hairy to end.

British Guiana: Onverwagt, Dec. 15, 1935 (J. Ogilvie). Resembles *M. maculata* Smith (*anthidioides* Rad.), but that has the last two sternites black-haired. There is a strong general resemblance to *M. fossoris* Smith (*leucocentra* Schrottky), but that has black hair on the two last sternites, and narrower abdominal bands.

***Megachile rufobarbata* sp. n.**

Female. Length about 11 mm.; rather slender, with stout but subparallel-sided abdomen, the last tergite rapidly descending, straight in profile; black, including mandibles, antennæ and tegulæ, the margins of tegulæ narrowly

reddish; legs black; wings dusky, with a very dark cloud in upper half of margined cell, and beyond the cell; ventral scopa white, with short black hair at end of last sternite, which is hairy to the end. Head broad; facial quadrangle approximately square; mandibles broad, with oblique margin; two strong apical teeth, and from the second a concave ridge to the poorly developed inner tooth (the inner angle), but set in this a broadly truncate tooth or lamella; cheeks and sides of face with snow-white hair; long red hairs projecting from beneath clypeal margin; clypeus very short and broad, very densely punctured, not shining, with pale hair at sides, and long black hairs on disc; clypeal margin in middle thickened, shining, and gently undulate; supraclypeal area shining in middle, strongly punctured at sides; vertex very finely and closely punctured; front and vertex with sparse long black hair; mesothorax and scutellum dull, the punctures excessively minute; a conspicuous slender white band in suture between mesothorax and scutellum; no distinct smooth line but a faint groove in middle of mesothorax; mesothorax and scutellum with sparse black hairs, but thorax with white hair in front; hair of pleura dull white, but a dense and very conspicuous white tuft on tubercles; a band of light hair above tegulæ; legs with white hair, orange on inner side of tarsi; spurs light red; hind basitarsi only moderately broad, but long; second to fifth tergites with narrow entire very pale fulvous bands, and a spot of the same at each side of first; apical tergite with fine white tomentum.

British Guiana: Plu Ruimveldt, Dec. 19, 1935 (J. Ogilvie). Related to *M. brethesi* Schrottky, which I saw in the Paris Museum. It agrees in having the wings dark fuliginous along the costa, and the white hair of cheeks and sides of face. *M. brethesi* has narrow white bands on the first three tergites. There is a superficial resemblance to *M. tuxtla* Cresson.

***Halictus (Chloralictus) guianensis* sp.n.**

Female. Length about 5 mm.; head and thorax green, abdomen black; head broad-oval, with the clypeus strongly produced; more than lower half of clypeus black, shining, with very coarse punctures; mandibles with the apical half red; flagellum red beneath except basally; face below antennæ shining, evidently green, but front dull and blackish, its lower part shining; mesothorax dullish, olive green, with small punctures; scutellum rather more shining; area of metathorax dull, bluish; mesopleura dark green; tegulæ dark brown; wings hyaline, with dull pale red stigma and pale nervures, the outer recurrent and intercubitus evanescent; hair of head and thorax thin and dull white; legs black, with the small joints of tarsi more or less pallid; abdomen shining, without hair-bands; hind margins of tergites slightly pallid. Microscopical characters: face below antennæ rather sparsely punctured; front densely punctured, not striate; scape with minute shallow punctures.

tures; fourth antennal joint very short, about twice as broad as long, fifth a little shorter than third; region behind middle ocellus with very few minute punctures; mesothorax, minutely reticulated all over, with rather sparse minute punctures; scutellum with larger and sparser punctures on disc than on hind part of mesothorax, but in the middle the punctures are relatively crowded; area of metathorax semilunar, well defined, with rather weak, not dense, radiating plicae which reach the margin, best developed at sides; tegulae large, impunctate, dark brown marked with pale reddish; hind spur with three stout blunt spines.

British Guiana: Onverwagt, Dec. 14 (J. Ogilvie). Seven, all but two in bad condition. The dull mesothorax and other characters at once separate this from *H. potaroensis* Ckll. The face is narrower and the clypeus more produced than in *H. paitensis* Ckll. The longer head and dull mesothorax at once separate it from such species as *H. balboae* Ckll., *H. hypochlorus* Ellis, and *H. chrysonotus* Ellis. There are several points of resemblance to *H. lessepsi* Ckll., but that has dusky wings, with very dark brown stigma.



## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

Meeting of May 21, 1935

A regular meeting of the Society was held on May 21, 1935 in the American Museum of Natural History; President Schwarz in the chair with twenty members and eighteen visitors present.

Mr. Hall presented the treasurer's report, as follows:

On hand January 1, 1935 .....	\$755.21
On hand May 1, 1935 .....	822.50

Mr. Pierre Noël, formerly with the Service Technique d'Haiti, was introduced to the Society. Mr. Noël said a few words in English, and then, on being urged, continued in French to say that he was glad to be present at the meeting and to be able to exhibit his insect portraits to the Society. The portraits exhibited by Mr. Noël were exceptional for their clarity, faithful reproduction and color.

Mr. Davis exhibited specimens of cicadas used in preparing his paper on "New Cicadas with Notes on North American and West Indian Species," published in this JOURNAL, 1935. Mr. Davis discussed the peculiarities of the specimens from the various islands of the West Indies; the inverted S on one insect and the Kaiser's helmet on the pronotum of another, which would probably cause Hitler to destroy the whole collection. Formalin for preserving colored insects, except those that are any shade of red, has been found, by Mr. Davis, to be the best medium to use. Mr. Davis mentioned the efficacy of a bean shooter, equipped with a bag of shot, in bringing down cicadas.

Mr. Nicolay was called on next. His excuse for continued absence from the meetings of the Society lay in the fact that he has become more interested in collecting insects while the programs of the Society meetings are tending more and more toward an interest in their extermination! He would, however, gladly accept from the members any advice on collecting during August in Newfoundland. This was freely given. Mr. Nicolay then went on to state that he had done some spring collecting at Lake Greenwood on April 28 and had found the orange tips in their prime; also the cicindellids were plentiful. He had been disappointed in the collecting at Mt. Piscah in North Carolina in the fall of 1934.

Mr. Heineman, another member, seldom present at the meetings, said he had spent several weeks in Florida in March. At De Leon Springs, he observed a field literally alive with *Papilio* and had taken seven different species there.

During the spring, Dr. Curran had taken two Diptera new to New York State. He had also observed a cicindellid burrowing in the sand.

ELIZABETH S. ENGELHARDT, *Secretary*.

## Meeting of October 1, 1935

The meeting was called to order at 8:15 P. M., with President Schwarz in the chair. There were twenty-eight members and guests present. In the absence of the Secretary, Dr. Ruckes was asked to act in that capacity, *pro tem*.

Dr. Melander gave a résumé of his 22,000 mile tour through the National Parks and Forest Areas of the Rocky Mountains and West Coast. He collected approximately 20,000 specimens, or about one per mile of his trip. The trip was made by car and trailer; the winter was spent at Riverside, Cal., which Dr. Melander described as an entomological paradise. The entire trip took fifteen months.

Mr. Davis reported on a camping trip he made in Cape May County, New Jersey, during which time he studied the song of *Tibicen latifaciata* to determine the difference between this cicada and *T. winnamanna*. The former sings only in the full daylight while the latter's singing period always extends into the evening. He also reported the expected appearance of his new species of cicadas, specimens of which he offered as exhibits.

Dr. Ruckes, speaking for himself and Dr. Klots, gave a résumé of an 8,000 mile trip to collect on the higher peaks above timberline in New Mexico, Colorado and Wyoming.

Mr. Kisliuk explained how new pests might be introduced through the importation of large quantities of foreign crops when our native crops do poorly. This was true for 1935 when the country had to import enormous quantities of broom corn, principally from the Argentine.

Mr. Crawford reported a new project in studying thrips of New York City. During the summer sixty-five out of the ninety-five recorded species for the state were discovered within the boundaries of the city. It was furthermore discovered that thrips have piercing rather than rasping mouth parts and are therefore potential vectors for plant mosaics, just as much as are the Hemiptera.

Mr. Hall made a trip to New Hampshire, collecting on the higher hills and procured specimens of *Brenthis montinus* Scudder.

Mr. Notman spent part of his summer, as usual, in New England and in Washington, D. C. While collecting on Mt. Desert Island he procured specimens of *Cicindela sprada* which is probably a valid geographically variety of *C. limbalis*.

Dr. Moore stated that he had poor success in raising insects this summer in view of the fact that the humidity was too high and most of his live stock became moldy.

Mr. Moennich, collecting at Alpine, N. J., recorded the abundance of carabid beetles, which otherwise are only occasional in this locality. *Calosoma scrutator*, *C. wilcoxi* and *C. frigidum* were found in appreciable numbers.

Mr. Comstock stated that he had begun work as Curator of Arthropoda in the Newark Museum during the summer. He reported progress and increasing interest in his new undertaking.

Mr. Forbes remarked upon his beginning studies in Entomology under

the tutelage of Dr. Hungerford at the University of Michigan Biological Laboratory.

Mr. Blanton retraced Dr. C. W. Johnson's trip through New England collecting Tachinidæ and Syrphidæ. He was fortunate in procuring most of Johnson's species from type localities. He spent some time studying the types of trypetid flies in the Museum of Comparative Zoology at Harvard. He obtained new records for Long Island, *Rivellia* sp. (Otididæ), *Trupanea mevarna* Walk., and *Paroxyna* sp. (Trypetidæ).

Mr. Farrelly and Mr. Bauer spent some time at Lakehurst and Montauk Point taking mutillids. The former is by far the better locality.

Mr. Schwarz told of his trip abroad. He visited the British Museum and as usual was cordially received by the members of the Entomology Department. He spoke of the attractive habitat groups that are on exhibit in the Zoological Gardens and the fact that the Gardens boast a house for the exhibition of invertebrates including insects.

HERBERT RUCKES, *Secretary pro tem.*

#### Meeting of October 15, 1935

A regular meeting of the Society was held on October 15, 1935 in the American Museum of Natural History; President Schwarz in the chair with thirty members and twenty visitors present.

The topic of the evening's discussion given by Mr. Schwarz and Mr. Huntington was "Collecting in the Cauca Valley of Colombia, S. A."

Mr. Schwarz described their trip from New York to Columbia, early in January 1935. They flew over the familiar buildings at Barro Colorado Island and over the Canal to Panama City. They entered Colombia at the seaport Buenaventura. The journey from the coast up into the Cauca Valley by train was an uncertain and delayed adventure, as is most train travel in Colombia. They were cordially received in the Cauca Valley and found that even the barefooted peons have the courtly manners of old Spain. The bathing facilities in this valley were most interesting and refreshing. A large font, known as the "Pila," is an integral part of many an open courtyard; the water pours out of a spout under which one can indulge in an invigorating shower bath. Historically the Cauca Valley is very old. Cieza de Leon was a member of an expedition through the valley in 1538 and, in the account of his wanderings, he describes one of the stingless bees found there, probably the first reference made to this insect in the literature of the Americas. Mr. Schwarz and Mr. Huntington found that weather conditions in the valley in January and February were not perfect for collecting. One hundred species of bees were taken of which one tenth were social bees, due, Mr. Schwarz believes, to the fact that these bees are more abundant in the American Tropics than in the Old World Tropics. Most of the ninety-three different species of beetles collected were flower visiting. Twenty-one families of Coleoptera were represented among the different species.

Mr. Huntington continued the narratives of Cauca Valley, illustrating his remarks with both moving pictures and colored slides of the trip and of the

Cauca Valley from Cali to Popayan. He showed pictures of numerous sites in and about the valley, including some of the charming old Spanish haciendas; animated scenes of a bull-fight, organized to raise funds for the carnival; glimpses of a tropical rain forest high up in the Andes; as well as scenes along the route from Cali to Popayan. Mr. Huntington's pictures gave the society a vivid idea of the rugged geography of this region of Colombia. They returned to New York early in March.

The meeting was then open to a general discussion of the addresses of the evening.

Mr. Kisliuk recalled his experiences in the public market of Buenaventura, where he found the native women entirely in control.

In speaking of the Diptera which Messrs. Huntingdon and Schwarz had brought from the Cauca Valley, Dr. Curran exhibited a specimen which, on first glance seemed to belong to the Syrphidæ. On inspection, however, it was found to be a new species of *Xylocopoides*, a genus known only on the coast of Brazil.

ELIZABETH S. ENGELHARDT, *Secretary*.

#### Meeting of November 19, 1935

A regular meeting of the Society was held on November 19, 1935, in the American Museum of Natural History with President Schwarz in the chair. Twenty-four members and thirty-five visitors were present.

Mr. George Rau of 647 Harrison Place, West New York, New Jersey, was proposed for active membership in the Society.

Mr. Davis exhibited a fine series of *Tibicen duryi* and *Okanagana magnifica* collected this past summer by Dr. Ruckes in New Mexico and Colorado. The largest of the *Okanaganas* were in Eastern Colorado, the farthest east that this species has been taken. These large cicadas are eaten with great relish by the Indians. Mr. Davis also showed an *Okanagana bella* taken in Eastern Colorado calling attention to the valve of the insect which was red, while specimens of the same species taken in Utah have a black valve. Mr. Davis then exhibited some curiosities: a female cactus-dodger, *Cacama dissimilis*, with a cactus needle protruding from the abdomen; an *Okanagana magnifica* which had flown against a pine needle, which was imbedded between the fifth and sixth abdominal segments; and a seventeen-year locust taken at West Point in 1911 which had mounted itself between the eyes on the sharp point of a flowering dogwood.

Dr. Spieth spoke on the data collected by him regarding the Journals published by various Entomological Societies and the cost of these Journals to the members of the Societies. It was agreed that although the cost of the JOURNAL of the New York Entomological Society is not included in the member's dues, the average number of pages a year and the quality of the JOURNAL compare favorably with those Journals of other Societies where the cost is included in the dues.

President Schwarz brought to the attention of the Society, for consideration, the recent discussion among members in regard to holding but one



meeting of the Society a month. The reasons cited for this change in policy being that there would be better attendance of the members at the meetings, and the fact that there is an increasing difficulty in obtaining speakers for two meetings a month.

Dr. Ruckes moved that this matter be laid on the table for discussion until the next meeting.

President Schwarz then introduced the speaker of the evening, Dr. John Hendley Barnhart of the New York Botanical Garden. Dr. Barnhart's subject was "Plants as Insect Traps"; an abstract of his talk follows:—

All animal life is dependent, either directly or indirectly, on plant life; whereas no plants are entirely dependent on animal life for their subsistence. It is not known why a few plants have developed a very elaborate mechanism for the capture and digestion of animal life. These elaborate ensnaring mechanisms may be compared with a hollow trap in some cases, and in others with the spring trap which folds together, thus catching the animal. In the case of the hollow type, the cavities are invaginations of the epidermis, swollen leaf bases being the simplest form of this type. Lantern slides were shown of the *Utricularia* (Bladderworts) with their highly developed acidia or bladders lying under water. These aquatic plants capture a great many larvae especially mosquito larvae.

Pitcher plants are equipped with a large reservoir more or less covered by a hood or lid. Slides were shown of the *Cephalotus* of Australia; *Heliamphora* of South America; *Sarracenia*, the true pitcher plant, native to this continent; the *Darlingtonia*, California's pitcher plant, with the translucent hood to confuse the trapped insect; and *Nepenthes*, seen in hothouses, with the beautifully colored pitchers upright from the ends of the pendent leaves.

The "catch-flies" use sticky surfaces to ensnare their prey. In this group, sticky areas are found near each node of the plant. There are tentacles on the leaves of the Sun-dew (*Drosera*) which close over the prey in the manner of slow-acting traps.

The aquatic *Aldrovandia*, common in parts of Europe, bears a striking resemblance in structure to the terrestrial *Dionaea* or Venus Fly Trap of this continent. In the opinion of the speaker, the sticky surface type of trap developed into the spring trap of the *Dionaea*. In this group, the spring trap reaches its highest development, the Venus Fly Trap operating with lightning-like rapidity.

ELIZABETH S. ENGELHARDT, *Secretary*.

#### Meeting of December 3, 1935

A regular meeting of the Society was held on December 3, 1935; President Schwarz in the chair with twenty-three members and thirteen visitors present.

Mr. George Rau of 647 Harrison Place, West New York, New Jersey, was elected an active member of the Society.

Mr. Henry Dietrich of 1086 North Broadway, Yonkers, New York, and Mr. Paul T. Richard of West Nyack, New York, and Mr. Werner Marchand of 114 East 18th St., New York City, were proposed for membership in the Society.

The matter of holding but one meeting of the Society each month, laid on the table at the preceding meeting, was brought before the Society.

Dr. Horsfall moved that the President appoint a committee to draw up an

amendment to the By-Laws to authorize the holding of but one meeting each month (excepting June, July, August and September). This motion was seconded and carried.

President Schwarz appointed Doctors Lutz, Curran and Ruckes to draw up such an amendment.

Dr. Lutz moved that the Secretary notify all members, through the Bulletin, of the amendment to be proposed and discussed at the meeting of December 17 and to be voted upon at the Annual Meeting of January 7, 1936. This was carried.

Mr. J. C. Crawford gave a talk on Thysanoptera titled "A general account of the Order Thysanoptera."

There followed a general discussion by Messrs. Weiss, Comstock, Schwarz, Blanton and others.

ELIZABETH S. ENGELHARDT, *Secretary*.

#### Meeting of December 17, 1935

A regular meeting of the Society was held on December 17, 1935, in the American Museum of Natural History; President Schwarz in the chair with twenty-two members and eleven visitors present.

The following were elected active members of the Society: Mr. Henry Dietrich, 1086 North Broadway, Yonkers, New York; Mr. Paul T. Richard, West Nyack, New York; Mr. Werner Marchand, 114 East 18th St., New York, N. Y.

In the absence of Dr. Lutz, Chairman, Dr. Curran reported for the committee appointed to draw up an amendment to the By-Laws to authorize the holding of but one meeting of the Society each month (excepting June, July, August and September). The committee reported as follows:

Amend Article IV by omitting the word "first" from the second sentence, making that sentence read: "All of whom shall be elected annually by ballot at the regular meeting in January and shall hold their offices for one year or until others are elected in their places.

Change section 1 of Article XVII to read as follows: "There shall be held one regular meeting of the Society each month from October to May inclusive at 8: 00 P. M. on the third Tuesday of the month."

Dr. Curran went on to discuss the advisability of this proposed change in number of meetings from the viewpoint of:

1. Those working in entomology every day, who would, perhaps, prefer but one meeting a month;

2. Those whose only chance to discuss entomology is at the meetings of the Society and who would, therefore, prefer the continuation of the two meetings every month;

3. Those who naturally enjoy the entomological discussions twice a month.

Dr. Curran concluded his remarks by suggesting a round table discussion of the collection and taxonomy of insects at one of the two meetings each month; and at the other meeting, a formal paper.

Mr. Davis expressed his approval of Dr. Curran's suggestion.

Dr. Horsfall stated that in his opinion the type of programs of the past created in collectors a feeling that the formal paper filled the period of the meeting too fully for any informal discussion of specimens. However, the instructive and more formal paper should be continued and Dr. Horsfall suggested that one or two members be appointed as the leaders of the informal round table meeting.

Dr. Leonard felt that a greater number of meetings during the year gives a greater opportunity for attendance by those members who are able to come only irregularly.

Dr. Ruckes stated that the average attendance of from twenty-five to thirty members is a great as can be expected and that the holding of but one meeting a month would, in all probability, not tend to increase this average attendance. In his opinion, the fifteen minutes for miscellaneous business intended for the discussion of insects during each meeting was a fallacy and had proved to be unsatisfactory. He stated that many members would not be satisfied with one meeting a month.

President Schwarz then appointed a nominating committee as follows:

Dr. A. L. Melander

Ernest L. Bell

John D. Sherman, Jr.

The speaker of the evening was then introduced. Dr. F. W. Metzger spoke on "Attractants for Insects with Particular Reference to the Japanese Beetle." Attractants may be divided into three groups, those of sex, those of light and those furnished by chemicals. Very little work has been done on attractants although the work with oriental fruit moths and other insects is increasing. Poison bait is used in scouting for insects and eventually will be used in collecting. Dr. Metzger then explained the use of geraniol, eugenol, and phenamethyl alcohol as attractants for Japanese beetles. Dr. Metzger illustrated his remarks on the development and use of the Japanese beetle trap with lantern slides. In closing, Dr. Metzger stated that, in his opinion, any insect can be attracted to a trap provided its background is known.

Following Dr. Metzger's paper there was a long discussion of its various aspects to which most all of those present contributed.

ELIZABETH S. ENGELHARDT, *Secretary*.





# The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943.

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

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WILLIAM T. DAVIS

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of the

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Devoted to Entomology in General



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# JOURNAL

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## New York Entomological Society

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DECEMBER, 1936

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### RECENT DEVELOPMENTS IN THE USE OF ELECTRIC LIGHT TRAPS TO CATCH THE ASIATIC GARDEN BEETLE<sup>1</sup>

BY HAROLD C. HALLOCK

DIVISION OF JAPANESE AND ASIATIC BEETLE INVESTIGATIONS,  
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE,  
UNITED STATES DEPARTMENT OF AGRICULTURE

#### THE ASIATIC GARDEN BEETLE AS A PLANT FEEDER

The Asiatic garden beetle (*Autoserica castanea* Arrow) is primarily a pest of ornamental and vegetable garden plants. In ornamental gardens such plants as aster, chrysanthemum, dahlia, phlox, and rose are especially preferred, but many others are attacked to some extent. In vegetable gardens, carrots are most attractive to the beetle, but beans, beets, cabbage, peppers, turnips, and other plants are often seriously injured. Because of the extensive feeding that has occurred on these plants in the heavily infested areas, studies of light traps have been carried on in an effort to catch the beetles and to protect the plants from damage by the insect.

#### ANNOYANCE CAUSED BY BEETLES IN LIGHTED PLACES

The Asiatic garden beetle is attracted to bright lights around stores and places of outdoor amusement in such large numbers

<sup>1</sup> The work reported in this paper was conducted under the general supervision of I. M. Hawley. Considerable assistance in the construction of traps was given by A. R. Whitcraft. The writer desires to acknowledge helpful suggestions from S. G. Hibben, Westinghouse Lamp Company, and the use of electrical equipment furnished by Mr. Hibben.

that the proprietors of such places have repeatedly complained that customers are driven away. Places which suffer most often from these nightly flights are carnivals, baseball parks, golf driving courses, dog race tracks, road stands, open-air restaurants, swimming pools, and similar brightly lighted establishments in the New York and Philadelphia suburban areas.

Almost any kind of electric light will attract the Asiatic garden beetle; the more powerful the light, the greater the numbers of the insect attracted. At golf driving courses lighted by batteries of powerful flood lights, thousands of beetles sometimes collect on the poles beneath the lights and on all objects in the lighted area. They have been so abundant on automobiles parked beneath these flood lights that a handful of beetles could be gathered in one sweep of the hand over the top of a car. In such places the insects fly about and alight on persons in the lighted area. This is very disconcerting to a person trying to make a good drive, and it is little wonder that the patronage of such places is affected. On one occasion several pints of dead beetles were collected from the surface of a highly illuminated swimming pool after a night's flight.

In the absence of bright lights, beetles are sometimes quite abundant in more dimly lighted places. On a warm night, 500 or more beetles collected on the screen doors of a suburban hotel. In this case there was only a faint light coming from the lobby, and each time the door was opened a few beetles made their way inside.

The blue mercury vapor lights, now so commonly used in illuminated signs, are especially attractive to the insect and thousands have been observed flying near them and resting on objects in their vicinity.

It seems likely, therefore, that the Asiatic garden beetle, as it increases in numbers in the area now infested and spreads into new localities, will be known not only for its destruction of plants, but in addition will be classed as a real nuisance because of the annoyance it causes to mankind.

#### LABORATORY STUDIES

In a series of laboratory studies on the reaction of the Asiatic garden beetle to lights of different colors, the apparatus used

consisted of a box divided into three compartments in a row, with sliding partitions separating the end chambers from the central compartment. In the outer wall of each end compartment were grooves for inserting colored glass plates or light screens, made by the Corning Glass works. The screens were illuminated by the use of clear electric light bulbs of various intensities placed at a fixed distance from the screens. Beetles were placed in the central compartment, and at the start of each trial the partitions between the end compartment and the central chamber were removed. The numbers of beetles in the end compartments at the conclusion of each trial were taken as the measure of the attraction of the lights being tested.

Although over 3,000 beetles were used in this work, the results were not entirely consistent, owing to the difficulty of equalizing the intensity of the lights being compared. For this reason, and because of the preliminary nature of the work, only the most obvious deductions will be presented in this paper.

It was evident that colors of short wave length near the violet end of the spectrum have the greatest attraction for the insect. The screens used, arranged in the order of their decreasing attraction, were red purple ultra, violet, blue purple ultra, daylight, dark blue, red, orange, yellow, and green. When the reactions of the oriental moth and codling moth were studied by Peterson and Haeussler, using the same set of color screens employed in this work, it was found that both insects showed a preference for purple ultra and violet lights (5).

When light from a mercury vapor lamp was tested against the artificial daylight screen, adjusted as nearly as possible to the same intensity, the former attracted  $2\frac{1}{2}$  times as many beetles as did the latter, but when the mercury vapor lamp was compared with the violet screen it was only three-fourths as attractive.

#### FIELD STUDIES

##### Status of Light-Trap Studies Prior to the Year 1932

The development of a light trap to assist in the control of the Asiatic garden beetle was first undertaken on Long Island in 1927. The result of the study during the first 5 years has been discussed in an earlier paper by the writer (4), and only the work of the past 3 years will be treated in the present paper.

The most effective trap developed by the end of the 1931 season was designated as the large funnel trap. The funnel of this trap, which was constructed of 30-gauge galvanized iron, was 4 feet in diameter at the top,  $1\frac{1}{2}$  inches at the bottom, and  $3\frac{1}{2}$  feet high. A large pail containing water with a 1-inch layer of kerosene oil was placed beneath the funnel. Beetles striking the inside of the funnel fell into the pail and were killed by the oil. A 500-watt daylight bulb was suspended above the center of the funnel, the bottom of the light being 5 inches higher than the outer edges of the funnel and approximately 6 feet above the ground. Catches in this trap in a single night during the seasons 1928 to 1931 reached a maximum of 21,000, and the total catches in this trap for an entire season ranged from 17,000 to 188,250 beetles. The wide variations in numbers of beetles captured were largely due to reductions in the beetle population resulting from the summer droughts of 1929 and 1930 (3).

#### LIGHT SOURCES USED IN TRAP TRIALS

Brief descriptions of the various lamps used in this study are given, as some of these lamps are not produced commercially and their characteristics are not generally known.

*Daylight Lamps.*—In trap tests during the past 4 years (1932–1935), daylight bulbs of two sizes, 100-watt and 500-watt, have been used. These bulbs have a faint blue tint and are proportionally richer than clear glass Mazda bulbs in the blue end of the spectrum. This effect is brought about by reason of an absorption of approximately 30 per cent of the red and yellow rays. No more short-wave radiation is added. Daylight lamps operate on 115-volt AC or DC lighting circuits without the use of a transformer. The 100-watt light (emitting about 980 lumens) fits a standard medium screw socket, but 500-watt light bulbs (6,370 lumens) usually are made to fit Mogul sockets.

*G-5 Mercury Vapor Lamp.*—This lamp, obtained from the Westinghouse Lamp Company, consumes 100 watts of electricity, taking about 5 amperes and in the clear glass bulb it emits a medium blue visible light having the general characteristics of a mercury vapor spectrum. The bulb is made of a quality of glass differing considerably from the ordinary clear glass used



on incandescent filament lamps, in that it transmits the long-wave region of ultra violet, of wave lengths from 2800A to the edge of the visible spectrum of approximately 4000A.

This particular lamp bulb is regularly available commercially, but as a precaution against screwing it directly into an ordinary lighting socket, in which case it would immediately burn out, it is provided with a slightly larger base and hence requires a special socket. In order to operate any of the type G-5 lamps they must be connected in series with a small choke reactance coil, a commercially available item of moderate cost. Then the combination of lamp and reactance may be connected directly to any 115-volt range alternating current supply. If direct current is to be used, as usually derived from farm light plants and portable field gasoline engine generators, a simple 20-ohm resistance replaces the above-mentioned reactance coil.

The rated life of this G-5 lamp is 500 hours. This bulb may be burned in any position. It is now in the market at a list price of \$5 each. It is approximately  $4\frac{3}{8}$  inches in diameter and 6  $\frac{13}{16}$  inches in maximum length.

*G-5 Black Mercury Vapor Lamp.*—This lamp, also obtained from the Westinghouse Lamp Company, has the same internal construction as the above-mentioned clear bulb G-5 lamp, with the exception that the bulb is of a special dark purple color, resistant to heat, and designed to cut out most of the visible radiation while permitting the passage of the longer ultra-violet rays, generally from about 3300A up to the visible spectrum.

In its method of burning and its current-controlling accessories it is identical with the clear bulb G-5 lamp, except that when procured commercially it has the standard medium screw base and consequently fits a standard lighting socket. It has the list price of \$8, but has heretofore been rated as a special lamp limited in usage to laboratory studies.

*G-1 Mercury Vapor Lamp.*—This particular lamp, similar to the type G-5, is recommended only in the clear glass bulb, having the same spectral quality of output but consuming approximately 45 watts at 2 amperes. Likewise it must be connected in series with its appropriate current-limiting reactor if on alternating current, or in series with a 50-ohm resistance if on direct current

circuits. Having the standard medium screw base, it may be used in any lighting socket but will burn out if not employed with the proper accessory.

It has a rated life of 500 hours and a list price of \$3.50. The maximum lamp bulb diameter is  $2\frac{5}{8}$  inches and the overall length is  $4\frac{1}{8}$  inches.

*Neon-Filled Glow Discharge Lamp.*—The special neon lamp used was made by the Westinghouse Lamp Company but is not a commercial item. It has the same internal construction and bulb as for the type G-5 lamp but with a low pressure of neon gas substituted for the mercury vapor. It operates with the same current-limiting reactance or resistance, but naturally emits the well-known orange-red neon spectrum color.

Its intensity or brightness in the visible spectrum is considerably higher than is the visible-spectrum brightness of the clear bulb type G-5 mercury lamp. It emits no measurable ultra violet radiation.

*Argon-Filled Glow Discharge Lamp.*—The argon lamp was made by the Westinghouse Lamp Company specially for these tests. It has the same internal construction and bulb as does the type G-5 lamp, but with a low pressure of argon gas substituted for the mercury vapor. It has the same current limits as the G-5 and neon lamps and emits a purplish visible light.

*High Intensity Mercury Lamp.*—This lamp, which is 13 inches long and 2 inches in diameter, emits a medium greenish-blue light. It is made to fit a Mogul socket and requires a transformer or reactor when connected directly to any 115-volt range alternating current supply. This lamp, supplied by the Westinghouse Lamp Company, is not a commercial item.

#### DETAILS OF TRAPS USED IN TESTS

Several styles of traps have been used in experimental tests during the past 3 years. The descriptions and dimensions of these are given, and for convenience in referring to them each type will be designated by a letter.

*Trap A.*—This trap, used in 1932, was the large funnel trap already described (folio 4) and used in previous years, but with the addition of a celluloid baffle consisting of four wings. A 500-

watt daylight bulb was suspended 2 inches above the intersection of the wings of the baffle.

*Trap B.*—In 1933 two traps exactly alike were built of galvanized iron and painted white (fig. 1). As in previously built traps, this one consisted of a large funnel that in this case was 4 feet in diameter at the top, 2 feet at the bottom, and  $3\frac{1}{2}$  feet deep. The funnel rested in a pan 4 feet in diameter and 6 inches deep, that was filled with water to a depth of 3 inches and covered with about 1 inch of kerosene. A metal baffle, the four wings of which met at right angles, extended 6 inches above the top of the funnel and 18 inches down into it. The trap was placed on a bench so that the light was about 6 feet from the ground. To support the lamp an iron pipe, with an arm at right angles from the top, was sunk in the ground at the side of the trap. In one of the traps of this type a 500-watt daylight bulb was used and in the other a G-5 lamp.

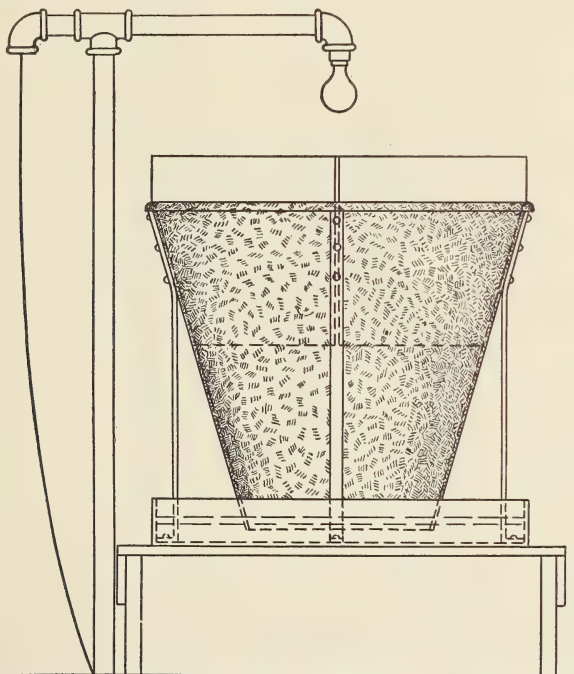


Figure 1.—Large trap with pan below, baffle at top, and light above baffle, used in 1933 (trap B).

*Trap C.*—In 1933 a trap much smaller than those previously used was tested (fig. 2). This consisted of a large aluminum baffle, the four wings of which were 24 inches high and 11 inches wide. An opening 6 inches across and 7 inches deep was cut in the top of the baffle at the intersection of the wings for the insertion of a light. The baffle was bolted to a galvanized iron tub 21 inches in diameter and 14 inches deep, in which beetles were captured in water covered with a 1-inch layer of kerosene. The trap was placed on a wooden support that raised the light to a height of about 5 feet above the ground. A G-5 lamp was used in this trap.

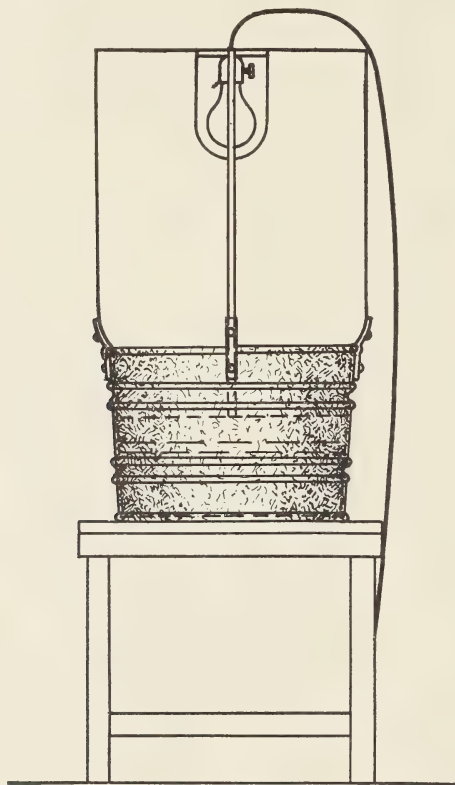


Figure 2.—Trap with light placed in center of baffle, used in 1933 (trap C).

*Trap D.*—Another small trap used in 1933 consisted of a funnel 18 inches in diameter and a baffle painted white, the four



wings of which were each 6 inches wide and 14 inches high. A screw top to hold a fruit jar was soldered to the bottom of the funnel, and in this jar the beetles were caught. This trap was suspended on a  $\frac{1}{2}$ -inch iron rod with an 8-inch arm at the upper end. In this trap the G-1 lamp and the G-5 black lamp were used.

*Trap E.*—In 1934 a trap with a funnel 12 inches in diameter at the top,  $\frac{7}{8}$  inch at the bottom, and  $11\frac{1}{2}$  inches deep was built (fig. 3). A baffle, the four wings of which were 6 inches wide

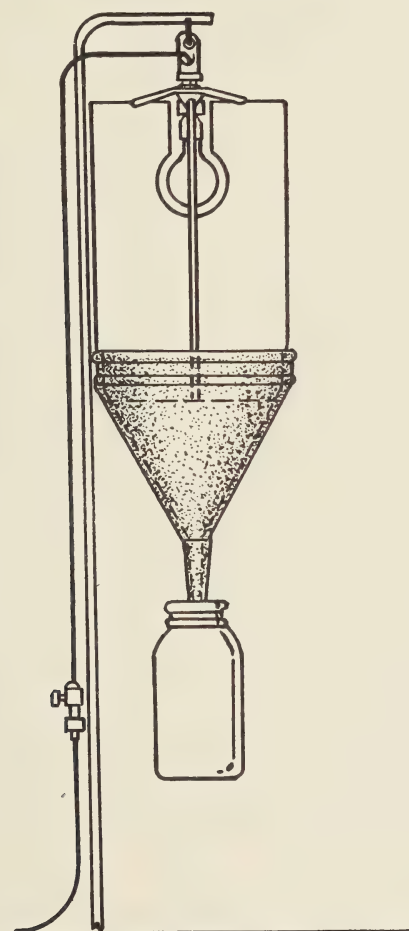


Figure 3.—Small trap with light in baffle, used in 1934. The trap is supported on an iron standard (trap E).

and 16 inches high and extending  $2\frac{1}{2}$  inches down into the funnel, was placed above the funnel, and the light was installed in a cutout at the intersection of the wings of the baffle. A screw top for attaching a fruit jar was soldered to the bottom of the funnel to receive the beetles entering the trap. The baffle and the inside of the trap were painted white and the outside of the funnel green. A 100-watt daylight light was used. The trap was supported on a  $\frac{1}{2}$ -inch galvanized iron rod with a 8-inch arm at the upper end so that the light was about 5 feet above the ground.

*Trap F.*—A trap similar to but larger than trap E was also built and tested in 1934 and 1935. The funnel of this trap was 18 inches in diameter and 16 inches deep, and the wings of the baffle were 9 inches wide and 20 inches high (fig. 4). The baffle and inside of the funnel were made of aluminum or were painted with white or aluminum paint, and the outside of the funnel was painted green. The light was located in an opening in the center of the baffle, and the beetles were caught in a fruit jar attached to the bottom of the funnel. In most locations the trap was suspended on a  $\frac{1}{2}$ -inch galvanized iron rod with an 8-inch arm at the upper end or on a support of the same general shape made of iron pipe. In this trap the G-5 lamp, the G-5 black lamp, the neon lamp, the argon lamp, and a 500-watt daylight bulb were used.

CONDITIONS UNDER WHICH THE EXPERIMENTAL WORK  
WAS CARRIED ON

Laboratory studies were carried on in 1932 in a sublaboratory given over to Japanese and Asiatic beetle investigations and located on Long Island, at Westbury, N. Y. Some of the field tests were conducted in a vegetable and flower garden located 1 mile north of the village of Westbury. This garden is on a large estate and is bounded on two sides by a thick planting of trees, on a third side by an uncultivated orchard, and on the fourth side by a cornfield situated on a hillside sloping toward the garden. The surroundings of this garden produced an isolated testing site with a heavy beetle population, which was being constantly augmented by the influx of beetles from the sodland in the orchard and a lawn between the garden and the trees that surrounded the buildings on the estate.

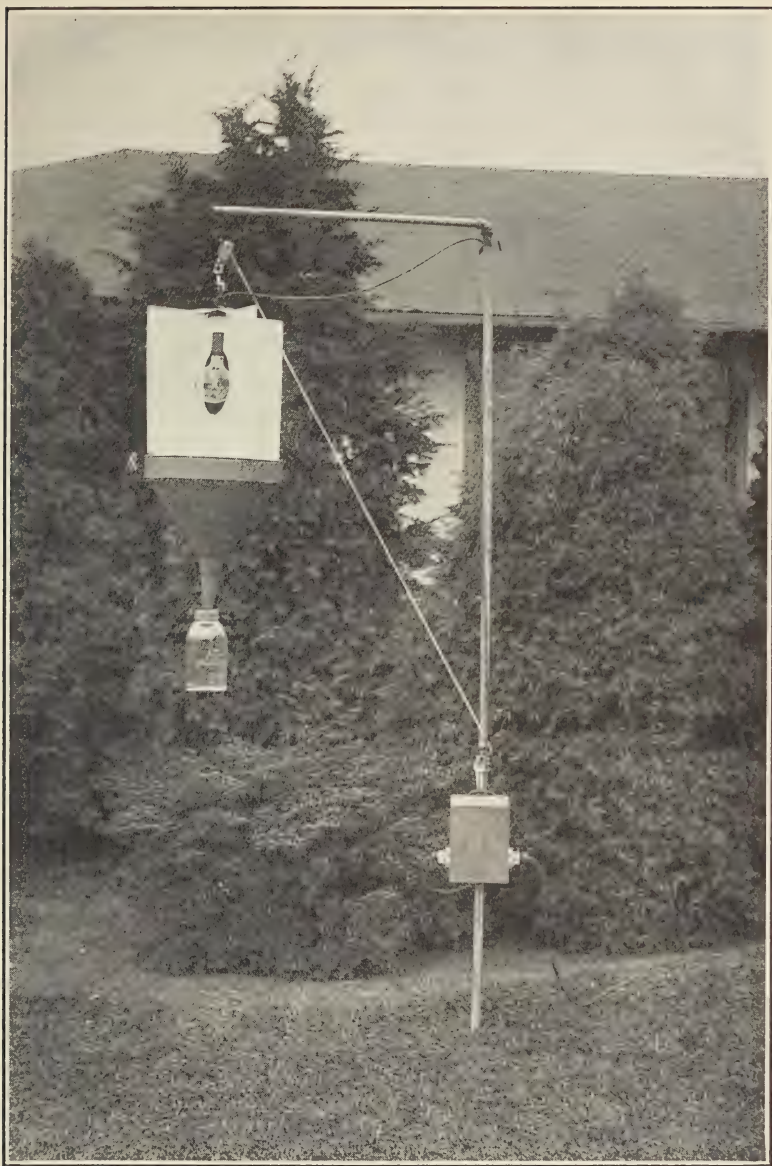


Figure 4.—Large trap, used in 1934 at a golf driving course. The trap is suspended beneath the flood lights used to light the course or suspended from special metal supports (trap F).

Other tests in 1933 and 1934 were conducted on Long Island in the village of Williston Park, under essentially city conditions. The houses are close together and each has a small lawn and an abundance of flowers.

During August, 1934, and the summer of 1935 tests were conducted at the Baltusrol Hills Golf Driving Course at Springfield, N. J.,<sup>2</sup> where powerful flood lights served to light the course during the evening. The flood lights attracted beetles from the neighboring fields, and a high concentration of beetles resulted.

#### CATCHES OBTAINED IN FIELD TESTS

In 1932 a 4-foot funnel trap (A), similar to those used in previous years, was equipped with a celluloid baffle and operated during the season at the Westbury testing station. The total catch was 96,333 beetles. The addition of the baffle was found to increase the efficiency of the trap.

In 1933 two 4-foot funnel traps (B) with metal baffles and large pans beneath the funnels were operated 60 feet apart at the Westbury testing station. In one trap a G-5 bulb was used and in the other a 500-watt daylight bulb. These traps were in operation a total of 27 hours on 10 evenings between July 8 and August 5. With the G-5 bulb an average catch of 1,932 beetles per hour was obtained, while with the 500-watt daylight bulb the catch averaged 1,672. The greatest hourly catch was 3,400 with the G-5 lamp and 3,100 with the daylight bulb. The pan beneath the funnel was added to this trap because it had been noted earlier that many beetles flying toward the light struck the outside of the traps and were not caught. In this trap such beetles fell into the pan and were killed by the oil. When the daylight bulb was used in this trap 25 per cent of the total catch of 45,144 beetles were taken in the pan outside the funnel. In the trap with the G-5 bulb 20 per cent of 52,183 beetles caught were outside the funnel.

A second trap (C) tested in 1933 consisted of a large 4-winged baffle made of aluminum attached to the top of a small washtub.

<sup>2</sup> Acknowledgement is made of the cooperation of Dr. T. J. Headlee, Entomologist of the New Jersey Agricultural Experiment Station, in the conduct of these tests.



The light, a G-5 bulb, was placed in an opening cut in the center of the baffle. When this trap was operated at Williston Park a total of 11 hours the catch averaged 1,630 beetles per hour.

A third trap (D) used in 1933 consisted of a 4-winged baffle and a funnel with a fruit jar attached to the bottom of the funnel to receive the beetles. This trap was used at Williston Park with a G-1 lamp on some nights and the G-5 black bulb on others. When the G-1 bulb was used the catch averaged 345 beetles per hour, while with the G-5 black bulb the catch was 258 beetles per hour.

In 1934 a new type of small trap (E), consisting of a 4-winged baffle above a funnel and a fruit jar attached to the bottom of the funnel to catch the beetles, was tested. To keep the cost of the trap and the operating expense as low as possible, a 100-watt daylight bulb, which does not require a reactor, was used. The average catch in this trap at Williston Park was 930 beetles an hour. On the most favorable evening 2,000 beetles per hour were taken.

In 1934 and 1935 a new trap (F), similar to type E, but larger, was tested. This trap consists of a 4-winged baffle, a funnel, and a fruit jar attached to the bottom of the funnel to receive the beetles. The trap was usually supported on a galvanized iron rod. In 13 hours of operation with a G-5 bulb at Williston Park an average catch of 1,490 beetles per hour was obtained. The greatest hourly catch was 2,780.

During August, 1934, five of these traps (F) were used at the highly lighted Baltusrol Hills Golf Driving Course at Springfield, N. J. They were operated beneath the flood lights that illuminate the course at heights of 8 to 20 feet from the ground. Pulleys were fastened to the cross arms bearing the flood lights, and with ropes over these the traps were raised and lowered to the heights desired. The traps were under observation a total of 7 hours on 3 nights and during this time 4 lamps were tested. The catches obtained with the various lights are given in table 1.

During July and August, 1935, from four to six traps were in operation on 27 nights at the golf driving course at Springfield, N. J., and over 300,000 beetles were caught. On several nights, when beetles were actively flying, traps were operated for 2 hours

TABLE 1.—CATCHES OF THE ASIATIC GARDEN BEETLE IN TRAPS  
AT SPRINGFIELD, N. J., 1934

<i>Type of light</i>	<i>Approximate number of trap- hours operated</i>	<i>Number of beetles caught per hour<sup>3</sup></i>		
		<i>Lowest</i>	<i>Highest</i>	<i>Average</i>
G-5 lamp .....	16.6	550	4,100	1,820
500-watt daylight .....	6.5	450	1,700	1,120
G-5 black lamp .....	1	400	950	675
Neon lamp .....	1	500	600	550
Check (no light in trap)	1	150	200	175

<sup>3</sup> The lamp filled with neon gas and the G-5 black lamp were used in traps at two locations for half an hour in each case. Two traps were also operated without a light for half an hour as checks. In order that the data from these trials may be compared with the other data, these half-hour records are multiplied by 2 to change them to an hourly basis.

beneath the flood lights, the catch was counted, and then the flood lights were turned off and the light traps operated for another hour. It was found that in the absence of other lights, the traps often caught as many in that one hour as in the two previous hours when they were operated in conjunction with the flood lights. For example, on one favorable night, one trap caught 5,875 beetles when operated at the same time as the flood lights and 6,825 when in operation alone. Most of the beetles drawn into the lighted area by the flood lights, and that were resting on poles and other objects near them, flew toward and entered the traps when the flood lights were turned off.

In most of the tests in 1935, G-5 mercury vapor bulbs were used in type F traps, as this is the most efficient combination of light and trap that has been found. Lights of other kinds were tested, however, to determine their efficiency in attracting beetles, and the hourly catches obtained compared with those of the G-5 mercury vapor lamp, which is rated as 100, were as follows: G-5 black mercury vapor lamp, 60; 500-watt daylight lamp, 58; high intensity mercury vapor lamp, 30; neon-filled glow discharge lamp, 28; argon-filled glow discharge lamp, 22; 100-watt daylight lamp, 17.

## FACTORS INFLUENCING TRAP EFFICIENCY AND USEFULNESS

About dusk Asiatic garden beetles leave their daytime hiding places in the soil in lawns and beneath their food plants, but only when the evening temperature is 70° F. or above do they fly about. This influence of temperature on flight has been observed each year since 1927 and is discussed in detail in earlier papers (1, 2, 4). After beetles have been flying about on a warm evening a fall in temperature below 70° F. will cause them to stop flying, but even on very warm nights beetles fly less actively late in the evening than they do at dusk. This reaction to temperature has a direct bearing on the usefulness of traps. During the past 7 years on Long Island, where most of the experimental work with traps has been carried on, the number of nights during a beetle season when the critical temperature of 70° F. has been reached has varied greatly. It would appear that in places as cool as Long Island traps are of little value in cool summers. In places farther south and farther inland the number of flight nights would naturally be greater.

All the electric lights that have been tested attract Asiatic garden beetles to some extent. White frosted bulbs are more attractive than clear bulbs, but less attractive than daylight bulbs. The mercury vapor lamps are the most attractive of any lights tested. From both laboratory and field tests it is evident that colors of short wave length near the blue end of the spectrum have the greatest attraction for beetles. The mercury vapor lamps are rich in visible blue light and in addition emit ultraviolet light of the larger wave lengths. A comparison of the catch with the G-5 bulb, which gives off both a visible blue light and ultraviolet rays, with that of the G-5 black bulb, in which the visible light is largely screened out, indicates that the visible part of the spectrum has greater attraction for the beetles. The neon-filled bulb that produces a red light had little attraction for the insect. The argon-filled bulb emits a purple light that would be expected to attract the beetle. In field tests, however, it showed little attraction. It is realized that our present knowledge of the qualities of light attractive to this insect is not exact, and it is highly desirable that the exact wave lengths or qualities of light to which the insect will respond most strongly be more definitely

determined. Such information should enable us to increase trap efficiency.

Up to a certain point, the greater the intensity of the light used the greater the numbers of beetles that may be taken in traps. That there may be a limit to the effective intensity of the light used is indicated by observations on the flight of the insect and from data collected from trap catches in which a 500-watt daylight lamp has been used. Many beetles flying toward a light of this intensity have been noted to veer from their course and to fly above or to the side of the baffle. When a 500-watt daylight lamp was tested against a G-5 mercury vapor lamp in traps with large baffles and funnels (type B) the catch with the daylight lamp was 85 percent of that obtained with the G-5 bulb, but when used in smaller traps with much narrower baffles (type F) only 61.5 percent as many were taken with this daylight bulb. When a 100-watt daylight bulb is used, beetles do not deviate from their course in approaching the light.

In early work with traps it was noted that more beetles were caught when objects near the trap were in shadow than when such objects were illuminated, as under the latter condition many beetles come to rest on lighted objects instead of entering the trap. The large funnels used in earlier traps, such as type B, shaded surrounding objects, and for this reason, in the early years of the work, traps of this kind were used in preference to smaller traps. However, as large traps are costly, hard to move about, and not adapted for general use, they have been replaced by smaller models. This lighting difficulty may usually be overcome by placing the trap in an open area away from high plants or other objects. In any case the trap should not be placed near plants that are favored as food by the beetles.

From the experience of the last four years it would appear that a 4-winged baffle with the light in a cutout area in the center of the baffle, as in types E and F, is the best arrangement for catching beetles. The five traps of type F used in 1934 differed from one another only in respect to the baffle. One had the baffle made of aluminum, in one it was made of galvanized iron and painted white, and the others were painted with aluminum paint. There was little difference in the catches obtained, but it is believed that



the trap with the aluminum baffle, possibly because of the less even diffusion of the light, is somewhat less effective than traps with painted baffles. It is advisable to have the baffle painted a light color because it has been found in other studies that more beetles are attracted to objects of light colors, such as white or aluminum, than to those of darker colors.

A trap with a funnel and fruit jar, as in traps E and F, is lighter in weight, easier to make, and easier to move from place to place than the larger traps. Such a trap may readily be supported on a  $\frac{1}{2}$ -inch galvanized iron rod, pointed at the bottom and with an arm 8 to 10 inches long at the top. When the rod is firmly worked into the ground, the trap may be fastened to the support through a hole near the outer end of the arm. The light in a trap should be about 5 or 6 feet above the ground.

Though the G-5 bulb attracts more beetles than any other light tested, it requires a reactor or transformer in the circuit. This makes the cost of a trap such as type F, using a G-5 bulb, rather high. In cases where the cost of the trap must be considered, a smaller trap such as type E that uses a 100-watt daylight bulb will catch many beetles—especially when not in competition with other lights.

There is need for some method of protecting persons from annoyance due to the swarms of beetles that collect in such brightly lighted places as golf driving courses. Though traps of type F in tests during 3 nights in 1934 and 27 nights in 1935 caught many beetles in such an area, it can not be said after only a little over one season's operation that sufficient data have been secured for recommending traps under these conditions. There is some indication that the capture of so many beetles helped to abate the nuisance at Baltusrol Hills Driving Course, but it is too early to make a statement on this point.

Although traps have not been unreservedly recommended as an aid in controlling the Asiatic garden beetle, the experimental traps being tested at the time have been widely copied and used on Long Island by people who have observed them in operation. Many beetles have been captured in this way, and most property owners who have tried traps feel that their use has been beneficial. It is extremely difficult to judge the degree of protection

secured by traps because of the possible influx of beetles from surrounding places. In some cases it has seemed that less foliage injury has occurred where traps have been operated at the edge of a garden than in gardens on other properties in the same area. It is still impossible, however, with our limited knowledge of Asiatic garden beetle populations in such places, to say that such apparent reductions in numbers are due solely to traps.

#### SUMMARY

Studies of light traps to catch the Asiatic garden beetle were started in 1927 and continued each year through the 1934 beetle season.

Because of its attraction to light this insect has become a nightly nuisance near brightly lighted places of business and amusement on warm summer evenings.

A funnel trap 4 feet in diameter with a 500-watt daylight bulb, in use from 1928 to 1931, caught as high as 188,250 beetles during a season.

Laboratory studies show that lights of short wave length near the violet end of the spectrum are most attractive to the beetle. Data concerning 5 types of lights and 6 types of traps that have been used in experimental work during the past four years are given.

In 1932 a trap with a 4-foot tunnel, similar to those used in previous years but with a celluloid baffle added, caught 96,333 beetles during the season.

In 1933 two traps with 4-foot funnels and a metal baffle were operated 60 feet apart. In one a G-5 bulb was used and in the other a 500-watt daylight bulb. The average catch with the G-5 bulb was 1,932 per hour and that with the daylight bulb was 1,672. A trap with a large aluminum baffle and the light in the center of the baffle was used with a G-5 bulb at another site, and the catch averaged 1,630 beetles per hour. In another trap a G-1 bulb and a G-5 black bulb were used; the catches averaged 345 for the former and 258 for the latter.

In 1934 two traps, similar in construction but differing in size, were built and tested. Each of these traps consisted of a funnel, a large baffle above, and a fruit jar below the funnel to hold the

beetles. In the smaller trap a 100-watt daylight lamp was used, while a G-5 lamp was used in the larger one. At the same testing site the catch of the former averaged 930 beetles per hour and that of the latter 1,490 per hour. Five of these larger traps tested at a brightly lighted golf driving course with 4 types of lights showed average hourly catches as follows: G-5 bulb, 1,820; 500-watt daylight bulb, 1,120; G-5 black bulb, 675; neon-filled bulb, 550.

In 1935 seven types of lamps were tested at the golf driving course used in the experiments of 1934. The relative efficiency of the lights based on the G-5 mercury vapor lamp as 100 was as follows: G-5 black mercury vapor lamp, 60; 500-watt daylight lamp, 58; high intensity mercury vapor lamp, 30; neon-filled glow discharge lamp, 28; argon-filled glow discharge lamp, 22; and 100-watt daylight lamp, 17 per cent.

Some factors, such as temperature, type of light, and construction of trap, that influence the efficiency and usefulness of traps are discussed.

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## FIVE LACE-BUG SPECIES NOT PREVIOUSLY RECORDED FROM NEW JERSEY

1. *Corythuca pallipes* Parsh. Found breeding but not numerous on Sweet Birch (*Betula lenta* L.) in High Point Park, Sussex County, VII-12-36.

2. *Corythuca coryli* O. & D. A rather heavy infestation on one clump of Hazelnut bushes (*Corylus americanus* Walt.) by the roadside between Great Meadows and Allamuchy, Warren County, IX-15-36. This is a small but striking species rather strongly fasciated with black. The hood is especially high, wide and handsome.

3. *Corythuca pallida* O. & D. Scattered and not numerous on the leaves of one Red Mulberry (*Morus rubra* L.) in a wooded ravine near Jericho, Cumberland County, IX-13-35. A fairly large, amber-tinted species very vaguely fasciated.

4. *Leptostyla clitoriae* Heid. On *Meibomia obtusa* Vail, near Prospertown, Monmouth County, IX-18-35. Found also on other species of *Meibomia* growing in semi-shaded places near Trenton, Mercer County, and Medford, Burlington County, in September, 1936. This is considerably smaller than *L. heidemani*, O. & D., and is conspicuously fasciated with black.

5. *Gargaphia solani* Heid. This species was found October 2 and 3 in three small patches of egg plant in Yardville, Mercer County, and Burlington and Bridgeboro, Burlington County. It is also well established in Gloucester, Monmouth and Salem counties. All stages were noticed, the nymphs congregated in dense patches on the lower surface of leaves. In the adult the basal and subbasal antennal joints are dusky, the sides of the paranota are wide and subangular with a dusky patch in the angle. The hood and margins of paranota strongly ciliate. General color buff, the hemielytra with several of the transverse veins black. Disk of hemielytra dusky basally and apically.

ROBERT J. SIM



THE EXTERNAL MORPHOLOGY AND PHYLOGENETIC POSITION OF THE WOODLAND CAVE CRICKET (*CEUTHOPHILUS BREVIPES* SCUDDER; ORTHOPTERA; TETTIGONIIDÆ)\*

BY ASHLEY BUELL GURNEY  
UNIVERSITY OF MINNESOTA  
UNIVERSITY FARM, ST. PAUL, MINN.

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Dr. T. H. Hubbell determined examples of the specimens used in this study as *Ceuthophilus brevipes* Scudder, and this kind service is greatly appreciated by the writer.

INTRODUCTION

The purpose of this paper is to furnish, in one work, the detailed external morphology of an orthopteron which, from an evolutionary standpoint, is among the most primitive of all saltatorial Orthoptera. Although published accounts of portions of the external anatomy have been made available by Drs. Crampton, Walker, and others, no complete morphological study of a native American Rhaphidophorine has been made.

Since Scudder erected the genus *Ceuthophilus* in 1862 more than fifty species have been described. From the point of view of a systematic study of these insects, therefore, it is well to have available a complete account of the morphology of one species to use as a basis for indicating the true relationships of the structures used in the taxonomy of the group.

\* Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Massachusetts State College, Amherst, Massachusetts, June, 1935.

Crampton (1923c) has suggested that *Ceuthophilus* may be involved as a carrier of disease organisms. If such should prove to be the case, as appears reasonable, any information regarding the biology and relationships of such a vector may be considered worthy of recording.

Probably the morphology of *Ceuthophilus* is most interesting to the student of insect phylogeny. The close relationships of orthopteroid insects were recognized by Packard (1883) but at that time a careful comparative analysis of the sclerites had not been made. Even earlier, Scudder (1869) had written on the arrangement of the families, but he placed the Gryllidæ and Tettigoniidæ in advance of the Acrididæ because of the greater development of songs, social habits, and the elongate nature of the ovipositor:

Marcovitch (1920) summarized the subject of orthopterous phylogeny and the tree shown by him (Fig. 4) indicates the probable phylogenetic position of the principal groups. The one correction to be made in this tree is that the Tettigoniidæ seem to be directed along the lines of the Acrididæ, with the Gryllids branching in the opposite direction from a point near the base of the Tettigoniids, rather than that the crickets and katydids followed parallel lines apart from the grasshoppers as his tree indicates.

Throughout the present study of *Ceuthophilus* a comparative study of the sclerites has indicated the close relationship of the Grylloblattids, Rhaphidophorines, Gryllacrine, and Stenopelmatines. The crickets clearly have close affinities with the primitive Tettigoniids while such forms as the Tridaetylines show qualities in their makeup which indicate an origin in the same stock, but these characters develop further in the higher Tettigoniids and thus lead directly to the grouse-locusts and finally to higher grasshoppers.

The main features of the head and abdominal structures of *Ceuthophilus* have been described by Crampton, Walker, and Yuasa in the papers cited, together with a discussion of evolutionary sequence. The chief original work of this paper is the part dealing with the thoracic sclerites and these are among the most important of all the body structures.

It is hoped that by bringing together the available information on the morphology of this primitive insect a better understanding of its phylogenetic position will result; also that it may aid future taxonomists within the group to locate the structures important in classification.

#### THE HEAD

The head capsule and its appendages do not differ greatly from the corresponding structures of *Stenopelmatus*, which Crampton (1930) has discussed in detail. The head capsule of *Stenopelmatus* in its general features appears rather more broadly rounded in the dorsal area than in the case of *Ceuthophilus*; the antennæ are decidedly more centrally located in *Ceuthophilus*. In these respects *Ceuthophilus* has departed further than *Stenopelmatus* from the primitive type of head capsule represented in *Grylloblatta*. The migration of the eyes toward the vertex points to the higher Tettigoniid type such as *Scudderia*, *Orchelimum*, and *Neoconocephalus* which leads up to the Acrididae. At the other end of the evolutionary scale the eyes are located far down the genæ, as in Isoptera and Dermaptera, which lead to *Grylloblatta*, as discussed by Crampton (1926a, 1932) and Yuasa (1920).

*Head capsule:* As shown in Fig. 3, the dorsal region of the head capsule of *Ceuthophilus* is oval in outline. The *coronal suture cs* is plainly but strongly demarked and terminates in a small triangular spot near the eyes. In this connection the fastigium of the Stenopelmatine *Licodia cerberus* Rehn of Cuba (see Rehn, 1930, Fig. 2) should be mentioned. There are no frontal sutures or epicranial arms in *Ceuthophilus* as there are in *Gryllus*, *Stenopelmatus*, or *Grylloblatta*. The entire region about the eyes and coronal suture is smooth and rather hard. The *parietals par* are the areas on each side of the coronal suture. The areas above the *eyes e* are known as the *temples te*. The *frons f* is just below and between the antennæ while the *genæ ge* are the areas each side above the subgena or *basimandibulare bm*. The latter is a small sclerite which is closely associated with the small *basimandibular membrane bmm*, and lies above the base of the *mandible md*. The margins of the *frontal pits fp*

are somewhat more heavily sclerotized than the surrounding *clypeus c* and *gena*. The frontal pits represent the external openings of the invaginations which form the forward arms of the *tentorium* or *pretentorium pt* shown in Fig. 1.

*Eyes*: The compound eyes *e*, like those of *Stenopelmatus* and *Grylloblatta*, are rather small in comparison to the eyes of most other primitive types of Orthoptera such as Dictyoptera and Gryllidæ. Crampton (1930) has suggested that this reduction of the eyes may be in keeping with the nocturnal habits of these insects (*Ceuthophilus* is nocturnal) and his suggestion is given support by the fact that the eyes of *Gryllotalpa*, which tunnels in soil, are distinctly smaller than those of *Gryllus*, a diurnal surface dweller. The number of facets in each compound eye of *Ceuthophilus* is about three hundred. Ocelli are lacking.

*Antennæ*: The antennæ are long and filiform and vary in number of segments from seventy-five to one hundred and sixty or more in some cases. In some individuals the antennæ are twice the body length. The *antennale an* (Fig. 2) is a delicate ring which bounds the membrane at the base of the *scape sc*. A small projection of the antennale is known as the *antennifer af*. The *scape sc* is the largest segment and rather flat. The *pedicel pd* is short and somewhat bulbous. The next segment, the *post-pedicel ppd*, is considerably longer than the pedicel and assumes the cylindrical form which occurs in the remainder of the antennal segments. The shorter intermediate segments are called *short brachymeres sb* and the more slender ones toward the tip *slender dolichomeres sd*. Additional names have also been applied to the segments in allied Orthoptera because of the differences in size and shape.

*Tentorium*: The inner supporting framework or tentorium of the head capsule of *Ceuthophilus* is formed according to the generalized type discussed by Comstock and Kochi (1902) and Imms (1929, p. 45) in which the chief structures are posterior, anterior, and dorsal arms, and the body of the tentorium. Just as furcæ and apodemes are invaginations of the external wall of the thorax and abdomen, so the tentorium represents invaginations of the head capsule.

When a potash preparation of the head capsule is studied in



frontal aspect the *anterior arms pt* (Fig. 1) are seen extending backward from the frontal pits where the invaginations occur. The support given to the mandibles which perform the most important work of the appendages of the head may be easily understood. The *dorsal arm st* is a small branch which is attached distally, in *Ceuthophilus*, near the cephalo-mesal margin of the eye. The *posterior arms poc*, resulting from invaginations, the external manifestations of which are the *gular pits gp* near the base of the basicardo, fuse with the anterior arms to form a broad central plate, the body of the tentorium or *eutentorium eu*. The posterior arms are the chief strengthening elements of the margins of the occipital foramen. The *postgenal process pp* bears the *postgenal acetabulum pga* and is separated from the *gena ge* by the *postgenal suture pgs*. The *parastomium psto* is a marginal area extending along the inner ventral edge of the postgenal process.

The commissures connecting the dorsal brain with the suboesophageal ganglion pass through the *neuroforamen nf*, an incision at the bases of the anterior arms. The commissures leading from the suboesophageal ganglion to the prothoracic ganglion pass between the flaring rims of the occipital foramen to the thorax. The semicircular *neuroforamen nf* is probably evolved from the closed structure found in Dictyoptera which leads finally to the entirely fused type exhibited by *Gryllus*. It may be noted that *Grylloblatta*, figured by Walker (1931b), is more like *Gryllus* in this respect than *Ceuthophilus* or *Stenopelmatus*.

*Occipital region:* The *occipital condyles occ* are the points of articulation of the head capsule with the *laterocervicale lc* (Fig. 13). When the external features of the occipital foramen are examined, a flaring band is seen along each side near the gula. This band is the "maxillaria" of Yuasa (1920, p. 262). Dorsad of the condyles the occipital foramen is less heavily sclerotized and the rim is little more than the strengthened margin of the cranium. As Walker (1933, p. 317) states, the occipital suture is not complete at this point.

The *paroccipital tendon pat* and *euoccipital tendon eot* are attached to the rim of the cranium, and the tendons serve as points of attachment for muscles moving the head.

*Clypeus and labrum:* The *clypeus c* is separated from the *frons f* by a well-marked fronto-clypeal suture. The postclypeal and anteclypeal areas are not plainly apparent in *Ceuthophilus*. The outline of the *labrum la* is shown in Fig. 3. The union with the clypeus is strong but allows some movement.

*Mandible:* Fig. 7 shows the insect's right (dextral) mandible as it appears in posterior view. There are three faces and a somewhat triangular base. The *ginglymus gi* is a shallow pit at the base of the frontal face of the mandible. The pit forms an imperfect hook which fits into a niche at the base of the clypeus. The *gnathocondyle* or *hypocondyle h* is a rounded projection which articulates in the *postgenal acetabulum pga* borne on the *postgenal process pp*. The chief tendons which move the mandible on its "rocking" points, the ginglymus and gnathocondyle, are the *flexor ft* which is the heavier of the two because it performs the actual crushing operations of chewing food and the *extensor et* which moves the mandible into an open position. Anyone interested in the powerful muscles extending from the tendons into the head capsule may be guided by the work of Walker (1931b) who has figured in detail the musculature of the head of the allied *Grylloblatta*. The *gnathite gn* is a small sclerite which supplies the attachment of the flexor tendon to the base of the mandible. The *extensor tendon et* is attached directly to the mandible proper at the *epignath* or *extensor prominence ep*. The *gnathapex ga* is a sharp, curved hook for grasping and tearing. The *molar region m* appears as in Fig. 7 and is best adapted for grinding processes. The interior of the mandible is hollow.

*Labium:* The ventral aspect of the labium is shown in Fig. 5. Fig. 4, a dorsal view, shows how the *glossæ gl* arise from the *glossigers gg* near the point where the latter join the *labial stipites li*. The *paraglossæ pg* are also borne by the glossigers. The *palpigers ppg* bear the three-segmented *labial palpi lp*. The *mentum mn* is composed of two regions the posterior of which is more darkly sclerotized. The *gula gu* and *submentum sm* comprise one sclerite, but the former portion is darker colored so that it appears distinct.

The labial structures of *Ceuthophilus* resemble very closely those of *Stenopelmatus* and *Gryllus*.

*Maxilla:* When the ventral surface of the head is examined, the maxilla appears as in Fig. 5. The *stipes s* and the narrow *parastipes ps* are separated internally by a ridge which affords a place of muscle attachment. The *basimaxillary membrane b* bounds the *parastipes ps* laterally. Fig. 6 shows a view of the internal surfaces of the cardo which is divided into *basicardo bc* and *disticardo dc*. The point labelled *d* is attached to the postgena near the gular pits and probably functions like a condyle. The *cardo-process cp* is an arm to which the *cardo tendon ctn* is attached. Crampton (1930) describes the manner in which the tendon probably moves the maxilla on the point *d*. The *endocardo ec* is an internal ridge which gives support to the sclerites and offers a place for muscle attachment. The *palpifer pf* is a small sclerite bearing the slender five-segmented *maxillary palpus mp*. The *basigalea bg* is well demarked and bears the *galea g*. The *lacinia l* is toothed as shown in Fig. 5 and is rather strongly sclerotized.

Crampton (1916a, 1923b), Walker (1933), and Yuasa (1920) have discussed in some detail the development of maxillæ in orthopteroid insects. The maxillæ of *Ceuthophilus* are very like those of *Grylloblatta* and *Gryllus*, but differ from those of the Blattidæ on account of the hood-like scoop borne by the galea of the latter. The Decticine genus *Peranabrus* (figured by Crampton, 1923b) shows galea and lacinia somewhat broader than those of *Ceuthophilus*. An examination of specimens of *Conocephalus* and *Neoconocephalus* shows an additional width of the latter appendages which points toward the broad structures found in Acrididæ. With respect to maxillæ, therefore, *Ceuthophilus* exhibits a primitive form.

*Hypopharynx:* The *hypopharynx hp* is a more or less fleshy structure attached to the base of the labium and situated between the labrum and labium as shown in lateral view in Fig. 9. It appears as in Fig. 8 when, with the labrum cut away, it is viewed from above. There are several lobe-like portions of the hypopharynx the apical portion of which is the *distilingua dl*. The *dorsolingua* or *surlingua sl* is the basal portion. The *basilingua bl* is a membrane which forms part of the basal attachment and is the location where the common salivary duct discharges fluid

into the mouth cavity. The oral opening of the oesophagus is near the dorsolingua so that ingested food passes above the hypopharynx. The *lingualora ll* is a small triangular sclerite at the base of the hypopharynx.

*Epipharynx*: The epipharynx is divided into posterior and anterior regions, labelled *poe* and *pre* respectively in Fig. 9. The epipharynx is the roughened inner surface of the labrum and clypeus which is modified to assist in the manipulation of food.

#### THORAX

While investigators have done less work upon the thorax of *Ceuthophilus* than upon the head and abdomen, this region is thought to offer even more valuable clues regarding the phylogenetic position than in the case of the latter. Tegmina and wings are entirely absent. Legs may be reasonably expected to show adaptation to mode of living and so are of scant evolutionary importance. The plates of the neck, pleura and sterna are of the greatest significance and will be discussed as the parts of the thorax are taken up in order.

#### PROTHORAX

*Neck Region*: The *precervicale pre* (Fig. 13) is a small divided plate which is hidden beneath the *pronotum pn*. The important cervical sclerite is the *laterocervicale lc*. Its anterior extremity articulates with the occipital region of the head.

Crampton (1926b, 1933, pp. 140-142) has shown that Blattids, Isoptera, and Mantids are very closely related because of the similarly divided laterocervicale and the mesally extending intercervicale. This latter condition is much different from that exhibited by *Ceuthophilus*. However, Figs. 65, 68, 80, 81, 86, and 94 of Crampton's 1926b paper show that with respect to this sclerite *Ceuthophilus* is a primitive member of the Saltatoria. It is similar to *Gryllacris* but most like *Grylloblatta*. Among the Gryllids, *Tridactylus* has an undivided laterocervicale which is directed mesally similarly to that of roaches. *Gryllus* has a partially divided sclerite which comes nearer *Ceuthophilus* in form, while *Oecanthus* is very like *Ceuthophilus* except for the division of the sclerite. Apparently the condition in *Oecanthus* leads to that occurring in *Tettix* and other Acridids.



*Pronotum:* The *pronotum pn* of *Ceuthophilus* completely covers the *episternum es*<sub>1</sub> and *epimeron em*<sub>1</sub>, but as Duporte (1919) has indicated, this is the result of the growing over of the pronotum rather than the forcing out of the pleural sclerites. The pronotum is smooth and polished. A like condition prevails in *Gryllacris* but in the related *Stenopelmatus* the beginnings of pronotal sulci are visible and in the remaining subfamilies of Tettigoniidae both the presence of sulci and the form of the pronotum point toward the condition found in Acrididae. The effect of wing muscles is of course entirely absent in *Ceuthophilus*. The pronotum of *Grylloblatta* does not extend ventrally so as to completely cover the pleural sclerites but is more like that of Dermaptera. Neither does the Gryllid pronotum show consistent similarities to that of *Ceuthophilus*. The pronotum of *Gryllotalpa* and *Tridactylus* is not very different from the *Ceuthophilus*-like forms but that of *Gryllus* is more flattened dorsally and that of *Oeonthus* is more suggestive of *Grylloblatta* or even of a Mantid. With respect to the pronotum, therefore, it appears that *Ceuthophilus* stands near the base of the whole Tettigoniid line leading directly to the Acrididae while the Gryllids represent an offshoot, possibly from a point near *Stenopelmatus*. It should be noted that although the Gryllids are an offshoot from the stem which leads to the Acrididae, they may exhibit qualities which constitute examples of development inherited from primitive Tettigoniids. Any such inheritance is interesting because certain of the same qualities were developed in the main Tettigoniid line leading to the Acrididae.

*Propleuron:* The *episternum es*<sub>1</sub> of *Ceuthophilus* is somewhat striking in appearance because of the bilobed condition. At the base it is fused with the *precoxale pr* and is closely affixed to the base of the *pronotum pn*.

The *epimeron em*<sub>1</sub> is a narrow curved sclerite at the base of which there is a tapering prolongation toward the *spiracle sp*. The *episternum es*<sub>1</sub> and *epimeron em*<sub>1</sub> are separated externally by the pleural suture and a narrow fold projects inwardly to form the *endopleuron* or *lateral apodeme*. This serves for the attachment of muscles and one-third of its length from the base an *apophysis apop* is attached which extends to it from the *furcasternum fs*.

The *trochantin tr* is a narrow sclerite between the base of the *coxa cx* and the *precoxale pr*.

*Prosternum*: The *presternum* has entirely disappeared in *Ceuthophilus*. The *basisternum bs* is fused with the *precoxale pr* and is present as a narrow transverse sclerite. The *furcasternum fs* is shaped like the *basisternum* and, as shown in Fig. 13, bears the *apophyses apop* which extend internally to the *endopleuron* already mentioned. The *spinasternum ss* is represented externally only by a small crescent-shaped sclerite in the midst of membrane. Internally, a small four-armed spine of the *spinasternum* is present, the anterior arms of which are each weakly forked again.

It is difficult to make a phylogenetic evaluation of the propleural and prosternal sclerites of *Ceuthophilus* upon a basis of present information. The chief available papers are those of Crampton (1926b), Duporte (1919), and Voss (1905). *Grylloblatta*, *Gryllus*, *Periplaneta*, and other forms have been figured, but in some cases the sclerites hidden by the overlapping pronotum have not been shown. A study of several Tettigoniid genera would be very helpful.

The roach represents a rather complex condition as compared to *Ceuthophilus*. The existence of both *precoxale* and *antecoxale*, the division of the *trochantin*, the frequent division of the *precoxale* and its separation from the *basisternum*, and the large size and frequent union of the sternal elements are characteristic of roaches.

A condition contrasted to that of the roach is found in the grasshopper *Disosteira* (see Crampton, 1918c; Duporte, 1919). The *episternum* and *epimeron* are reduced to narrow, tapering sclerites. A basal spur of the *epimeron* extends posteriorly as in *Ceuthophilus*. The pleural suture is vertical. The elements of the *prosternum* are united to form a triangular sclerite connected laterally to the *episternum*.

The condition exhibited in *Ceuthophilus* is intermediate between these two extremes, but distinctly nearer *Dissosteira*. *Grylloblatta* is both roach-like and grasshopper-like in these respects. The condition of the *prosternum* of *Gryllus*, *Grylloblatta* and *Tridactylus* indicates a transition to the grasshopper-like condition from a condition much like that of *Ceuthophilus*.

*Leg:* The outline and proportions of the fore leg are shown in Fig. 10. The *coxa* articulates with the base of the pleuron and the chief muscles concerned in allied species are discussed by Duporte (1919). The *coxa cx* is somewhat elongate and is grooved to receive the conical *trochanter tch* which articulates with it. Fig. 26 shows the mesal surface of the *coxa cx* and the *tendons ten* which pull the *trochanter tch*.

The *femur fe* is firmly joined to the *trochanter tch* and little movement is possible. The femur is grooved beneath and unarmed except for a single small spur near the apex on the inner side of the groove.

The *tibia ti* is cylindrical and of uniform diameter. It is armed with a pair of small apical spurs dorsally and four pairs of similar spurs ventrally.

The four-segmented *tarsus ta* is loosely articulated and in lateral view appears as in Fig. 10. The first, which may result from the fusion of two segments, and fourth segments are longest. The ventral surfaces of the tarsal segments are membranous and slightly dilated to form a pad-like or pulvilli-form condition.

Fig. 11 shows the chief structures important to the articulation of the claws or unguis. The *unguis ung* is curved, slender and unarmed. It articulates with the dorsal apical margin of the *distitarsus ta<sub>4</sub>* and is moved by the action of the *tendon ten* which pulls the *retractile plate rp*. There is no *arolium*. These structures compose the *pretarsus* of de Meijere (1901, p. 423) and are similar on the other two legs. The pretarsi of several Orthoptera, including *Ceuthophilus*, have been figured and discussed by Holway (1935).

The legs are variable in Orthoptera on account of different living habits and so are difficult to interpret from an evolutionary standpoint. However, the very large bilobed pads of the Japanese *Galloisiana* (see Caudell and King, 1924) and the distinctly bilobed pads on the third tarsal segment of *Scudderia* and allied genera may have some relation to the slightly dilated condition in *Ceuthophilus*. In general, the fore leg of *Ceuthophilus* is much like that of *Grylloblatta*. The number of tarsal segments does not seem to be important since in the Rhaphidophorine *Daihinia* the tarsi do not all have the same number of segments (see Caudell, 1916, p. 685).

## MESOTHORAX

*Mesonotum*: The *mesonotum mnn* of *Ceuthophilus* is narrower and slightly deeper than the *pronotum pn* but does not otherwise differ materially from it. The complete absence of tegmina and wings accounts for the chief differences between meso- and metanotum of *Ceuthophilus* and those of most Saltatoria. *Grylloblatta* does not show so much growth of the notum ventrally and neither does *Stenopelmatus*, but the nymph of *Melanoplus* (see Snodgrass, 1909, Fig. 55) is very like *Ceuthophilus*, showing that characteristics of *Ceuthophilus* persist in the ontogeny of such more highly evolved species.

*Mesopleuron*: A large part of the *episternum es<sub>2</sub>* is exposed below the overhanging *mesonotum mnn*. This sclerite is roughly triangular, is curved anteriorly, and has a prominent prolongation in the direction of the atrophied precoxale. There is a lengthwise suture as shown in Fig. 13.

The *epimeron em<sub>2</sub>* is largely concealed, but occurs as a narrow, curved sclerite beside the episternum. The cephalad portion extends beyond the *endopleural suture* as the *endopleuron* and is long and curved at the base. A smaller external hook is present at the caudal-ventral extremity.

The *trochantin tr* is a narrow crescent-shaped sclerite.

*Mesosternum*: The *basisternum bs* and *furcasternum fs* form a single broad transverse plate. The furcal pits mark the position of the internal *furcæ fur* each arm of which is unequally bifurcate while a median spina extends posteriorly and has two curved "horns" on either side. The *spinasternum ss* is a narrow sclerite which is not connected to the furcasternum.

As in the case of the prothorax, the pleuron and sternum of the mesothorax are considerably different from those of a roach. The pleural suture of *Grylloblatta* (Crampton, 1915) is slightly more horizontal than in the case of *Ceuthophilus* and the laterosternite is probably fused to the episternum in the case of the latter. In respect to the propleuron *Gryllus* (Duporte, 1919, Fig. 13) is much like *Ceuthophilus*, but the prothoracic epimeron is wider. Among the higher Tettigoniids the presence of wings brings about a change of shape and a specialization for articulation of wing ossicles. As Snodgrass (1909, pp. 537, 557, Figs. 43,



55, 56, 57, 70, 71) has brought out, the short-winged Decticine *Anabrus* has essentially the same form of pleuron as in adult Acrididæ although nymphal Acrididæ are not yet specialized for flight and so show a more primitive condition. A pleural ridge in the episternum of *Ceuthophilus* persists in Acridids.

The broad united *furca*- and *basisternum fs bs* of *Ceuthophilus* is intermediate between the very broad condition of *Dissosteira* and the broadly lobed condition of *Grylloblatta*. The *furca*-sternum and *basisternum* of the roach are more separated than in *Ceuthophilus* and so in respect to the mesosternum *Ceuthophilus* occupies a position near *Grylloblatta* and annectent to Acridids.

*Leg*: The *coxa cx* is shaped as shown in Fig. 16 and is grooved above. The *trochantin tr* is an important articulatory sclerite. A mesal view of the *coxa cx* and *trochanter tch* is shown in Fig. 22. The trochanter is freely jointed with the coxa but the joint with the *femur fe* is only slightly moveable. The latter is grooved beneath and armed with two small spurs, one apical spur on the mesal surface and the other externally on the ventral margin near the apex. The *tibia ti* is slender, cylindrical, curved at the base, armed with three small dorsal spurs in an irregular line, three pairs of ventral spurs and two pairs of apical spurs of which the ventral pair is the longer. The four-segmented *tarsus ta* with *ungues ung* does not differ materially from the prothoracic tarsus.

#### METATHORAX

*Metanotum*: The *metanotum mtn* is attached to the *mesonotum mn* by a fold of membrane and in life the anterior margin lies below the posterior border of the latter. The metanotum is longer and not so deep as the mesonotum.

*Metapleuron*: The *episternum es<sub>3</sub>* is roughly triangular in shape and a pleural ridge extends from the base nearly the entire length. It is very much like the *mesepisternum es<sub>2</sub>* except that the prolongation corresponding to the laterosternite of allied species is lacking.

The *epimeron em<sub>3</sub>* is likewise similar to the *mesepimeron em<sub>2</sub>* but the *endopleural apodeme* at the base is not so long as in the latter.

The *trochanter tr* is narrow and curved.

*Metasternum*: The *basisternum bs* and *furcasternum fs* form a semi-quadrate sclerite which is deeply cleft anteriorly. The *furca fur* are curved arms which are tri-furcate.

As Snodgrass (1909, p. 556) has stated, "Meso- and meta-pleura closely resemble each other" in Orthoptera. In general, the pleural sclerites of both segments show the same tendencies and a comparison of figures in the references cited leads to almost identical conclusions.

*Leg*: The posterior leg is shown in Fig. 14. The *coxa cx* is marked by a longitudinal scar externally. Mesally (Fig. 21) the coxa is divided by a median line into an anterior and posterior area. The *trochanter tch* is largely concealed as seen from an external aspect and the relationships are better shown in Figs. 21 and 15. The trochanter is composed of a wide basal rim and the trochanter proper. The articulatory process *X* is connected with the coxa and the *tendon ten* moves the trochanter. The trochanter fits over a small neck-like process of the *femur fe* and the femur and trochanter move as a unit just as in the non-jumping legs.

The *femur fe* is greatly enlarged basally to accommodate the huge muscles which move the *tibia ti*. The femur is deeply sulcate beneath and both lower margins bear small spines. The apex of the femur is modified to receive the base of the *tibia ti* which is shown in Fig. 18. The articulatory processes *X*, *X* and the two *tendons ten*, the lower of which flexes the leg while the upper one performs the action of leaping, illustrate the manner in which simple mechanical processes are utilized by these insects. Blatchley (1920, p. 20) states that the ventral apical lobes of the femur prevent the tibia from wobbling in leaping.

The *tibia ti* is slender and sulcate above. The margins of the groove are lined with small spines and there are five pairs of spurs which are slightly staggered. The three pairs of apical spurs are figured. The number of ventral spurs is variable. Usually there is one very small spur near the apex, but in some cases there is an additional pair nearby. The two hind tibiae of the same individual may differ in this respect. Fig. 12 shows a section of tibia with a *spur spu* removed to give a view of the *spur calyx spu c* in which it is set.

The four-segmented *tarsus ta* is very like that of the other body segments.

The form of the hind femora and tarsi is very variable in the genus *Ceuthophilus* and allied genera. Caudell (1916) has figured some of the forms important to classification.

#### ABDOMEN

The anatomy of the abdomen of *Ceuthophilus* is reasonably familiar to students of comparative morphology, due largely to the researches of Chopard, Crampton, and Walker in the papers listed. The terminal segments of each sex exhibit interesting features from the standpoint of a comparative study and will be discussed separately.

*Abdominal segments:* The abdomen of *Ceuthophilus* is sub-cylindrical in general appearance. Crampton (1933) has pointed out that in this respect *Grylloblatta* (which is much like *Ceuthophilus*) is more closely allied to primitive saltatorial Orthoptera than to roaches in which the abdomen is strongly flattened. Staining is necessary to show the exact extent of the sclerites. As shown in Fig. 19, the tergites  $t_{1-10}$  are separated by pleural membrane from the sternites  $s_{1-9}$ . A similar condition occurs in the Grylloblattids, *Stenopelmatus*, *Camptonotus* and, as far as the writer knows, among all higher Tettigoniids also. The tergites of *Oecanthus*, too, grade into pleural membrane, but *Gryllus domesticus* L. shows well-defined sclerites and a distinct area of membrane. In *Gryllotalpa* the membrane is somewhat folded and *Tridactylus* shows a condition in which the sternites and membrane overlap the tergites. In the Acrididæ, however, the opposite condition, in which the tergites have grown over the lateral margins of the sternites, is found.

Under a compound microscope the pleural membrane of *Ceuthophilus* shows many, small spines, most of which bear a seta at the base, and some occur on the tergites. It is interesting to note that these and the dorsal spines of *Pristoceuthophilus tuberculatus*, described by Caudell (1916, Fig. 15), may be homologous with those of *Galloisiana* mentioned by Caudell and King (1924, p. 54).

*Spiracles:* The abdominal spiracles of *Ceuthophilus* are eight

pairs in number and are located as shown in Figs. 13 and 19. The seven posterior abdominal spiracles are somewhat smaller than those of the thorax and first abdominal segment. Each spiracular opening is guarded by two small elongate sclerites. The structures of the spiracles have not been examined in detail here, but are described in the work of Vinal (1919) on *Dissosteira*.

The location of the spiracles of *Ceuthophilus* seems to be a primitive condition among Saltatoria. In all local Acrididæ except the Acrydiinæ the abdominal spiracles are borne by the margins of the tergites. As an example of the grouse-locusts, *Acrydium* has only the eighth spiracle present on the tergite. In *Gryllus*, *Gryllotalpa*, and *Oecanthus*, as in the Tettigoniids, all occur in the membrane, but in *Ripipteryx*, from Central and South America, the eighth is borne by the tergite and thus the latter and *Acrydium* are intermediate between the Tettigoniids and higher Acrididæ.

Among the Dictyoptera the spiracles of roaches (see Crampton, 1925) are borne by small sclerites known as subtergites or pleurites, while *Stagmomantis* has the spiracles on the tergites. The exact lines of evolution represented by the different positions of the spiracles are not well understood, but probably the subtergites are portions of the tergites. The subtergites are lost in Tettigoniids, but in the Acrididæ the tergites extend laterally and surround the spiracles.

#### TERMINAL STRUCTURES OF MALE

*Tergites:* The tergites slowly decrease in length toward the apex of the abdomen, but the ninth  $t_9$  is the first to be decidedly smaller than those anterior to it. The dorsal margin of the eighth tergite  $t_8$  shows a variety of specific variations within the genus and is utilized by systematists on this account. In *C. brevipes* sc. this margin is smoothly convex and scarcely rises above the level of the other tergites, but in other species it is emarginate, raised in the form of a crescent, or may be distinctly truncate. The ninth tergite  $t_9$  is slightly shorter dorsally than at the lateral extremities. It is sometimes practically concealed by the eighth tergite, depending upon the degree of extension of the intertergal membrane. The tenth tergite  $t_{10}$  is a very narrow sclerite which is frequently hidden by the ninth.



*Sternites:* The ninth sternite  $s_9$  differs from the other ventral sclerites in being modified as the subgenital plate. As shown in Fig. 19, it is partially divided near the base. An important feature of the subgenital plate is the apical membrane, which is in the form of curved "horns"  $ms_9$ , and which is used as a specific character in systematic work. The beginning student should not confuse these "horns" with the membranous, horn-like arms of the penis which are called parameres.

In the primitive *Grylloblatta* the ninth sternite bears a pair of coxites and the latter in turn styli. It may be that the posterior portion of the ninth sternite of *Ceuthophilus* represents the coxite and that the membranous "horns" are degenerate styli. According to Blatchley (1920, p. 602), the subgenital plate of the Gryllacrinae is deeply notched transversely and bears short obtuse styli. Karny (1934) has discussed and figured styli in both sexes of very small nymphs of *Rhaphidophora* sp. from eastern Asia. In higher Tettigoniids, such as *Neoconocephalus* and *Scudderia*, a transverse division of the sternite is not as apparent but styli are present. Gryllids bear no styli. Walker (1922, Fig. 58) has interpreted the structures of Tettigidea to include coxites and in higher Acrididae they are represented by the apex of the subgenital plate. With respect to the ninth sternite, therefore, *Ceuthophilus* shows a primitive condition.

*Cercus:* The *cercus ce* of the adult is slender, tapers to a fine point, and is non-segmented. As shown in Fig. 23, the apical portion has small irregular areas of heavier sclerotization which suggest segmentation but actual segments are not demarked. The cercus of the first instar nymph appears as in Fig. 20. Although difficult to see, three small segments are present. The basipodite or *basicercus bas* at the base of the cercus is shown in Fig. 25. In some specimens the two sclerites are imperfectly divided.

The cylindrical eight-segmented cerci of *Grylloblatta* and the nine-segmented appendages of *Galloisiana* are more like Plecoptera than the sub-triangular cerci of roaches. As noted above, the cerci of *Ceuthophilus* show affinities with a multi-articulate adult condition, and in *Pristoceuthophilus cercalis* (see Caudell, 1916, Fig. 17) five small segments are present. *Diestrammena*

and most Gryllids (the cerci of *Tridactylus* are two-segmented) possess very long, tapering, non-segmented cerci, but those of *Stenopelmatus* are slightly stouter and shorter than *Ceuthophilus* and may point toward the short, broad types of most higher Tettigoniids. A comparison of *Ceuthophilus nodulosus* (see Caudell, 1916, Fig. 10) with *Amblycorypha* or *Scudderia*, and *Pristoceuthophilus celatus* (l. c., Fig. 13) with *Conocephalus* shows two types of cerci in the more advanced subfamilies of Tettigoniidæ which apparently are presaged in the more primitive Rhaphidophorinæ. The broad, often blunt cerci of Acrididæ are well known as their modifications, especially in *Melanoplus*, are used in classification.

*Supra-anal plate:* The *supra-anal plate sa* is a sub-triangular flap, the apex of which extends above the anus. It is most heavily sclerotized at the margins and about a central depression. Hubbell (1934, p. 223) refers to a basal portion, the epiproct, and a smaller deflexed distal portion, the suranale. While these terms are in accepted systematic use, the term epiproct in a strict morphological sense applies to the tenth tergite, as it was so used by Crampton (1929, 1933, p. 151).

The supra-anal plate is characteristic of nearly all Saltatoria, though absent in roaches and mantids, and frequently is absent in Plecoptera. Hebard (1916, Figs. 14-16) has figured a small chitinous hook on each side of the supra-anal plate of the adult male *Stenopelmatus*. In many Gryllids and higher Tettigoniids the supra-anal plate is fused with the tenth tergite and in some Gryllids the line of fusion may be seen. The transverse line of demarcation is conspicuous in many Acrididæ, especially in nymphs as Walker (1922, p. 21) has stated. The paired arms, *furculeæ*, of *Melanoplus* are borne by the tenth tergite.

*Paraprocts:* The *paraprocts pa* (Figs. 25 and 27) are narrow sclerites which give support to the membrane ventrad of the supra-anal plate and between the cerci. They are variously known as laminae subanales and podical and parapodial plates. The drawings are made from stained potash preparations, but in the natural state each paraproct appears as a roughly triangular area. The paraprocts of *Grylloblatta* are similarly weakly sclerotized and though stronger in other Tettigoniids and crickets they

are seldom conspicuous as in *Ripipteryx* and *Tridactylus*. In Acrididæ they have undergone no great change of form except that heavier sclerotization has brought about broad flat plates.

*Pseudosternite*: The *pseudosternite pst* is a heavily sclerotized hood-like structure just anterior to the penis. It is supported laterally by *rami ra* and by endopophyses which extend inward from the arch *ar* which covers the ejaculatory duct leading to the penis. The postcornua or dorsal lobes *pc* are folds of the lower margin laterad of the arch. The roof of the pseudosternite is nearly flat in *C. brevipes* Sc., but is sharply gable-like in certain species; the arch, postcornua and rami are also subject to specific variation.

Walker (1922, pp. 24-28) has pointed out that, unlike the Rhaphidophorinæ, the higher subfamilies of Tettigoniidæ do not possess a well developed pseudosternite. Neither is it present in roaches and Grylloblatta, but it is prominent in most crickets and in *Gryllus* resembles that of *Ceuthophilus* which suggests that the crickets may have evolved from the lower groups of Tettigoniids. The pseudosternite of the Gryllids, especially in the case of *Oecanthus* (see Walker, l. c., fig. 46), shows a tendency to be nearer the penis than in *Ceuthophilus* and this also holds true in *Acrydium*. The pseudosternite of higher Acridids is well developed, resembles that of *Ceuthophilus*, and is valuable in systematic work.

*Penis*: The penis of *Ceuthophilus* is largely membranous, although the *ventral lobe lop* is strengthened and spinulose. The *parameres pm*, which are latero-anterior arms, and the lightly sclerotized area between them frequently are invaginated while in a resting condition and so are examined with difficulty. The ventral lobe is also partly invaginated at times and Walker (1922, pp. 24-28) has discussed the formation of a "spermatophore sac" preparatory to the extrusion of the spermatophore and its attachment to the female.

In order to appreciate the critical features of the female genitalia one must know something of the functions performed. Turner (1916) has outlined in general the breeding habits of the different families of Orthoptera and the question as to whether the sexual products are inclosed in a spermatophore is readily

seen to be important. The latter says that spermatozoa are transferred directly in Acrididæ, and so the strong pointed structures described in detail by Walker (l. c.) and Hubbell (1932) would appear useful. However, Uvarov (1928, pp. 53-56) describes spermatophores found in grasshoppers; they are apparently very small.\* Fulton (1931, pp. 227-231, Figs. 4 and 5) has described the structure of the spermatophore in *Nemobius* and Henneguy (1904, pp. 267-268, Figs. 272 and 273) has discussed the spermatophores of various groups and has given figures in the case of *Gryllus*. The parameres are heavily sclerotized in many higher Tettigoniids and may point toward the condition in Acrididæ; the long endapophyses of *Ceuthophilus* also seem to persist in the more advanced forms.

#### TERMINAL STRUCTURES OF FEMALE

*General features:* The eighth, ninth and tenth tergites  $t_{8-10}$  (Fig. 24) differ rather markedly in shape from the respective sclerites of the male. The eighth sternite  $s_8$ , which serves as a shield at the base of the lower valves  $vv$ , shows modifications in the direction of the egg guides of Acrididæ. The cercus, paraprocts and supra-anal plate are similar in both sexes. The important structures are those relating to the ovipositor and since they have been carefully described and figured by Crampton (1929) and Walker (1919b) in papers that are readily accessible, only the main features will be mentioned here.

The genital aperture opens between the eighth and ninth sterna into the inner valves  $iv$  which are completely inclosed by the larger dorsal valves  $dv$  and ventral valves  $vv$ .

*Ventral valves:* At the base of each ventral valve  $vv$  is the *basivalvula*  $bsv$  which is partly concealed by the eighth sternite  $s_8$ . A small triangular sclerite representing a part of the ninth sternum, the valvifer  $vf$ , serves as a point of attachment for both ventral and dorsal valves. Each ventral valve has a decided inner fold along the ventral margin and a narrow fold along the upper margin. The four apical teeth appear as figured.

\* An important paper by Mr. R. E. Snodgrass, "The Abdominal Mechanisms of a Grasshopper," (Smithsonian Misc. Coll. 94, 6, 1-99, 41 Figs., 1935) has recently appeared which includes a review of the knowledge of fertilization in Acrididæ.



The ventral valve is attached at the base to the basivalvula and by a slim ramus to the valvifer *vf*.

*Dorsal valves*: The dorsal valves are equal in length to the ventral valves and when the valves are closed overlap the upper margins of the latter. Near the inner ventral margin of the dorsal valve is a distinct sclerotized projection which may be called the *inner hook ih*. The superior apophysis *sap* is a subtriangular sclerite firmly attached to the base of the valve *dv* and the anterior point extends within the distal tergites as a point of attachment for tendons.

*Inner valves*: The inner valves *iv* are about two-thirds the length of the other valves and are held within the dorsal valves by the inner hooks *ih*. There are folds near the ventral margins of the inner valves and dorsally the two valves are joined as shown by Walker (1919b, Fig. 3). The ramus *rm* is a short bar at the base of each inner valve which extends within the body as a point of attachment.

Fig. 17 shows a ventral view of the developing ovipositor of a small female nymph. The left ventral valve, belonging to the eighth sternite *s*<sub>8</sub>, is cut away to better show the dorsal and inner valves developing from the ninth sternite. Practically a parallel condition prevails in *Stenopelmatus* and has been figured by Walker (1919b, 1919a) in *Conocephalus* and *Grylloblatta*. In the first of the two papers cited the latter author has presented a splendid series of figures and a thorough discussion of the types of ovipositors exhibited by the several Orthopteroid families. The advanced form shown by higher Tettigoniids has been discussed; also the differences exhibited by crickets and the way *Ripipteryx* and Acrydiinæ are primitive to higher Acrididæ.

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## ABBREVIATIONS

af	antennifer	gi	ginglymus
an	antennale	gl	glossa
apop	apophysis	gn	gnathite
ar	arch of pseudosternite	gp	gular pits
b	basimaxillary membrane	gu	gula
bas	basipodite	h	gnathocondyle or hypocondyle
bc	basicardo	hp	hypopharynx
bg	basigalea	ih	inner hook of dorsal valve
bl	basilingua	im	intervalvular membrane
bm	basimandibulare	iv	inner valve
bmm	basimandibular membrane	l	lacinia
bs	basisternum	la	labrum
bsv	basivalvula	lc	laterocervicale
c	clypeus	li	labial stipites
cds	cardosuture	ll	lingualora
ce	cercus	lop	ventral lobe of penis
cp	cardoprocess	lp	labial palpus
cs	coronal suture	m	mola
ctn	cardotendon	md	mandible
ex	coxa	mn	mentum
d	articulatory process of basi- cardo	mn	mesonotum
dc	disticardo	mp	maxillary palpus
dl	distilingua	m s <sub>9</sub>	membranaceous "horns" of 9th sternite
dv	dorsal valve	mtn	metanotum
e	compound eye	nf	neuroforamen or neural in- cision
ec	endocardo	occ	occipital condyle
em	epimeron	p	tentorial arch or trabecula
ep	epignath or extensor promi- nence	pa	paraproct
eot	euoccipital tendon	par	parietal
es	episternum	pat	parooccipital process
et	extensor tendon	pe	postcornua or dorsal lobes of pseudosternite
eu	eutentorium or body of ten- torium	pd	pedicel
f	frons	pf	palpifer
fe	femur	pg	paraglossa
fp	frontal pits or clefts	pga	postgenal acetabulum
fs	furcasternum	pge	postgena
ft	flexor tendon	pgs	postgenal suture
fur	furca	pl	postlingua or "linguaten- don"
g	galea	pm	paramere
ga	gnathapex		
ge	gena		
gg	glossiger (Basiglossa)		



pn	pronotum	sc	scape
po	pons valvularum	sd	slender dolichomeres of an-
poc	parocciput or posterior arms		tenna
poe	postepipharynx	sl	dorsolingua
pp	postgenal process	sm	submentum
ppd	postpedicel	sp	spiracle
ppg	palpiger	spn	spine
pr	precoxale	spu	spur
pre	precervicale	spu c	spur calyx
pre	pre-epipharynx	ss	spinasternum
ps	parastipes	st	supratentorium
pst	pseudosternite	t <sub>1</sub>	tergites of abdomen
psto	parastomium	ta	tarsus
pt	pretentorium	tch	trochanter
ra	ramus of pseudosternite	te	temples
rm	rami of inner valvulæ	ten	tendon
rp	retractile plate	ti	tibia
s	stipes	tr	trochantin of coxa
s <sub>1</sub>	sternites of abdomen	ung	ungues or claws
sa	supra-anal plate	vf	valvifer
sap	superior apophysis	vv	ventral valve
sb	short brachymeres of antenna	X, X,	fueral points

## CEUTHOPHILUS BREVIPES

## PLATE VII

- Figure 1. Anterior view of tentorium and neighboring parts.  
Figure 2. Antenna.  
Figure 3. Frontal view of head.  
Figure 4. Anterior view of glossae and paraglossæ.  
Figure 5. Posterior view of back of head.  
Figure 6. Inner surface of cardo and stipes.  
Figure 7. Posterior view of dextral mandible.  
Figure 8. Anterior view of hypopharynx.  
Figure 9. Lateral view of hypopharynx and upper and lower lip, with most of head capsule removed.

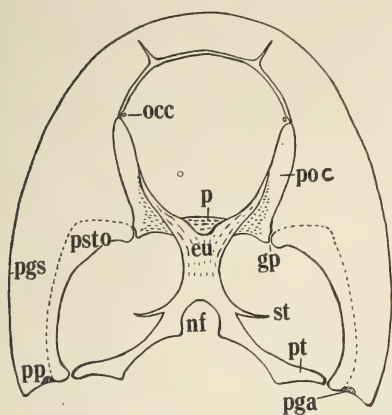


Fig. 1

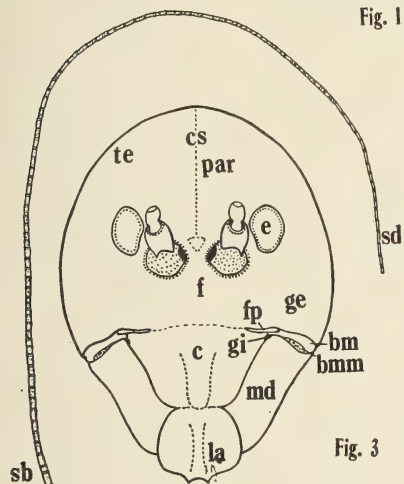


Fig. 3



Fig. 4

Fig. 2

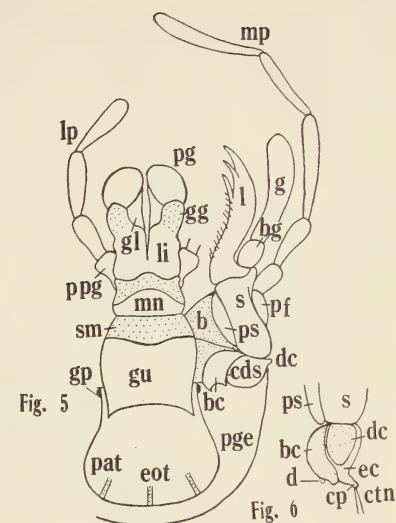


Fig. 5

Fig. 6

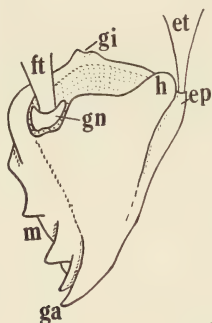


Fig. 7

Fig. 8

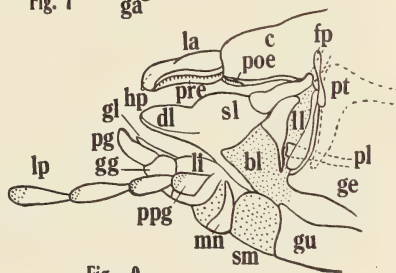


Fig. 9

## CEUTHOPHILUS BREVIPES

## PLATE VIII

- Figure 10. Lateral view of fore leg.
- Figure 11. Ventral view of pretarsus of fore leg.
- Figure 12. Section of tibia of rear leg.
- Figure 13. Lateral view of thoracic sclerites.
- Figure 14. Lateral view of rear leg.
- Figure 15. Mesal aspect of rear trochanter.
- Figure 16. Lateral view of mesothoracic leg.
- Figure 17. Ventral view of terminal abdominal segments of small nymphal female.



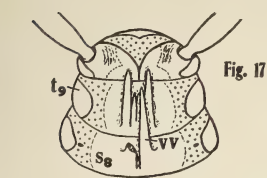


Fig. 17

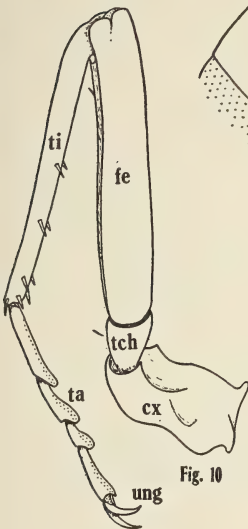


Fig. 10

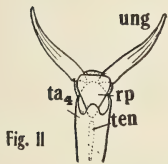


Fig. 11

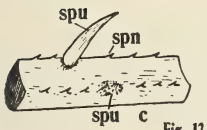


Fig. 12

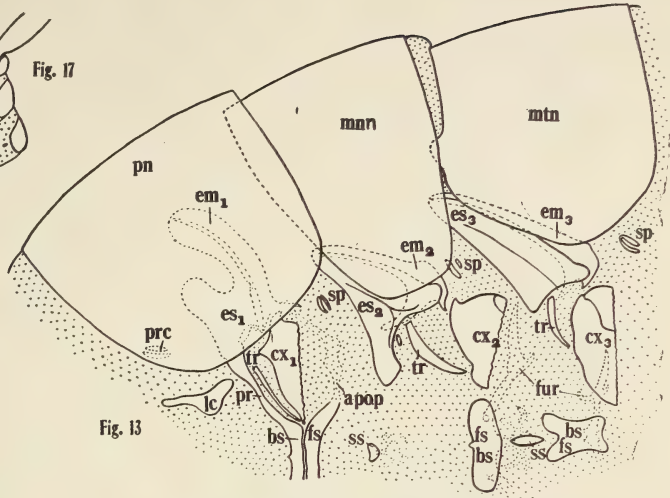


Fig. 13

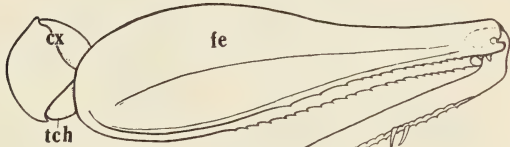


Fig. 14

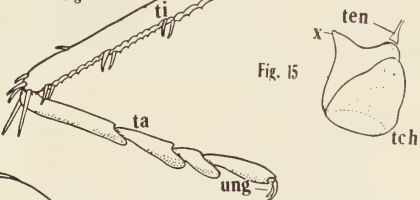


Fig. 15

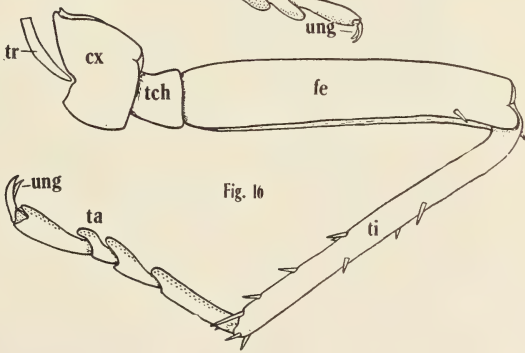
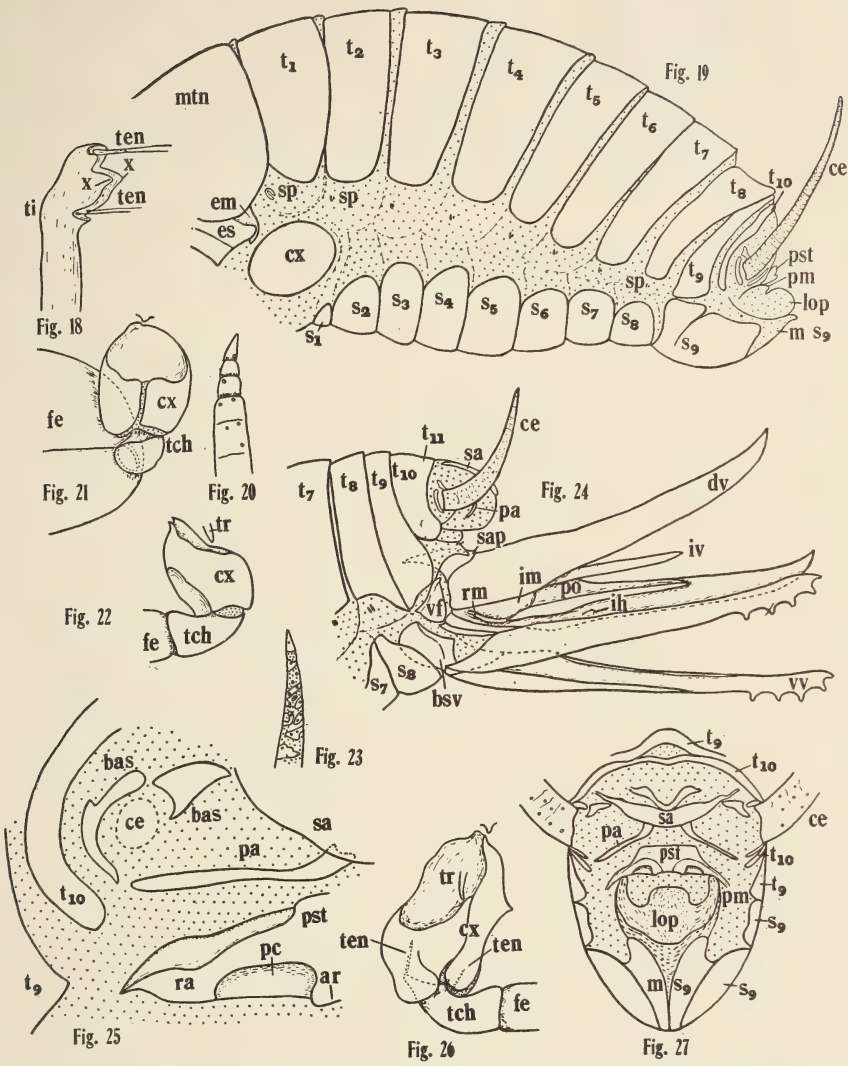


Fig. 16

## CEUTHOPHILUS BREVIPES

## PLATE IX

- Figure 18. Lateral view of base of rear tibia.  
Figure 19. Lateral view of abdomen of male.  
Figure 20. Apex of cercus of small nymph.  
Figure 21. Mesal aspect of base of rear leg.  
Figure 22. Mesal aspect of base of mesothoracic leg.  
Figure 23. Apex of cercus of adult.  
Figure 24. Lateral view of terminal abdominal segments of adult female.  
Figure 25. Latero-posterior view of region about base of cercus in adult male.  
Figure 26. Mesal aspect of base of fore leg.  
Figure 27. Dorso-posterior view of terminal abdominal structure of adult male.



## HESPERID LARVA DEFOLIATING KUDZU VINE

Recently my attention was called to the unsightly condition of a Kudzu-bean vine on a porch trellis in Riverton, N. J. Numerous larvæ of the Silver-spotted Skipper (*Epargyrgus tityrus* Fab.) were eating some of the leaves and using others, drawn together with silk, as individual shelters. Common locust is the usual food-plant.

The Kudzu-bean (*Pueria hirsuta* Schneid.) is a rapid-growing vine native to Japan and China. In America it is used as a porch screen and rarely as a forage crop.

ROBERT J. SIM



THE RELATION BETWEEN THE DEGREE OF  
FINENESS OF PYRETHRUM POWDER PRO-  
DUCED BY DIFFERENT PERIODS OF  
GRINDING TO TOXICITY TO IN-  
SECTS AND TO DETERIORA-  
TION BY LIGHT AND AIR\*

BY CHARLES LOREN SMITH, M.Sc.  
RESEARCH ASSISTANT, RUTGERS UNIVERSITY

INTRODUCTION

The increasing demand for insecticides non-poisonous to human kind has made it imperative that the efficiency of the present materials, such as pyrethrum powder, be increased to the utmost in an effort to replace the poisonous materials now in use.

The writer found there was little information on the effect of particle size of pyrethrum powder on toxicity, and on its deterioration by light and air. Methods of protecting pyrethrum powder from deterioration have only been touched upon by investigators. Work was, therefore, undertaken towards improving the efficiency of pyrethrum powder when applied as a dust or in water suspension.

The purpose of the work reported in this paper is to establish definite relationships:

- (1) between the fineness of pyrethrum powder and its toxicity to insects,
- (2) between the fineness of pyrethrum powder and its rate of deterioration when exposed to light and air, and
- (3) between the fineness of pyrethrum powder and the degree of protection afforded by certain pigments and anti-oxidants from deterioration by light and air.

\* This investigation was made possible by a joint fellowship established by McCormick and Company, Inc., of Baltimore, Maryland, and Derris, Incorporated, of New York City. The data presented in this paper is part of a thesis presented to the faculty of Rutgers University in partial fulfillment of the requirements for the degree of Master of Science.

## REVIEW OF LITERATURE

*A. Effect of Fineness of Pyrethrum Powder on Toxicity to Insects*

Only slight mention has been made in the literature of the relationship between fineness of pyrethrum powder and toxicity. Work on improving the physical properties of dust materials has consisted in the main of altering the carrier used rather than in varying the fineness of the ground flowers.

Richardson (12) states that coarse powder (15 to 45 mesh) gives an extractive efficiency of about 80 per cent, whereas a fine 200 mesh powder gives a significantly higher extractive efficiency. Gnadinger and Corl (6) showed that the achenes contained 92.4 per cent of the total pyrethrins. The achenes are not broken up until a fineness of 200 mesh is reached.

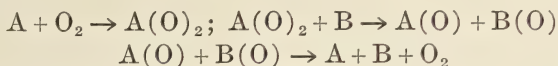
*B. Effect of Fineness of Pyrethrum Powder on Rate of Decomposition by Light and Air*

Hartzell and Wilcoxin (7) found that commercially ground pyrethrum powder exposed to sunlight, ultra-violet light, and heat resulted in a loss of pyrethrins determined chemically, and a loss of toxicity to aphids. Tattersfield (15) reports that both artificially prepared dusts and ground pyrethrum flowers lose their insecticidal activity on exposure to light and air. He states: "Both light and air play an important part in the process of inactivation, as samples of Kieselguhr-pyrethrum or talc-pyrethrum dusts stored in closed vessels in the dark or exposed to the air in the dark are relatively stable; also samples exposed to light in an atmosphere of CO<sub>2</sub>, nitrogen, or in vacua lose little of their toxicity under the same conditions of illumination; samples exposed in oxygen, however, rapidly lose their activity."

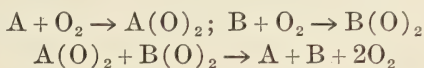
*C. Protection of Pyrethrum Powder from Loss of Toxicity by Addition of Pigments or Anti-Oxidants*

A great deal of work has been done with anti-oxidants in relation to the stabilization of oils, fats, vitamins, etc. No better explanation for the action of anti-oxidants has been advanced than the theory of antagonistic peroxides given by Moureu and Dufraisse (10). They suppose the peroxide A(O)<sub>2</sub>, oxidizes the

anti-oxygen B, with the formation of a peroxide B(O), while it is itself transformed into another peroxide A(O). The two peroxides A(O) and B(O) are antagonistic, and mutually destroy each other, with regeneration of the three original molecules A, B, O<sub>2</sub>.



Another hypothesis, is that of a direct auto-oxidation of the anti-oxygen; in this case we have the following cycle:



It is noted that A, O<sub>2</sub> have been taken from the state of *activated molecules* at the moment of their combination, and returned to the mixture in an inactivated state.

A great amount of experimental data has been accumulated supporting this theory. Tattersfield (15) reports that "the incorporation of anti-oxidants with talc-pyrethrum and Kieselguhr-pyrethrum dusts retards loss of activity due to exposure to light and air." Some of the phenolic compounds tested gave a considerable measure of protection.

Jones, *et al.* (9) used lampblack with rotenone (equal parts) and secured a measurable protection from decomposition upon exposure to light and air. Neither bentonite nor the substances naturally occurring with rotenone in powdered derris root protected rotenone from decomposition. Hamilton and Ben Amotz (unpublished data), working on the theory that certain colored pigments might protect pyrethrum from light, ran tests on a large number of pigments. It soon became evident that the protection was not due to the color of the pigments. The writer continued this work under Dr. Hamilton's direction. It was found that those pigments which have a high index of reflection or absorption of the wave lengths of light injurious to the toxic principles of derris or pyrethrum powder and which also had good covering properties were most efficient in protecting the powder from deterioration. While this field of study has not been exhausted, the best protecting agent found when this work

was started was titanium dioxide, and it was used in the tests reported herewith.

#### EXPERIMENTAL METHODS

##### *Preparation of Pyrethrum Flowers for Testing*

A quantity of high quality Japanese flowers ground for percolation was procured from McCormick & Company, Inc., of Baltimore, Maryland. In order to secure a material which was of fairly uniform size for a starting point these flowers were ground for five hours in a ball mill, then screened through a 50 mesh wire. The residue from this screening was ground in the ball mill for another five hours and screened as before. The residue from the second screening was discarded. When a sufficient quantity of flowers had been prepared in this manner they were thoroughly mixed. Analyses were run on the flowers before and after grinding.

##### *Analyses of Pyrethrum Flowers*

	<i>Before Grinding After Grinding</i>	
Pyrethrins I and II (Gnadinger and Corl copper reduction method) .....	0.91 per cent	1.11 per cent
Non-volatile petroleum ether extract .....	4.37 per cent	4.50 per cent
Moisture .....	5.61 per cent	6.28 per cent
Total ash .....	6.39 per cent	6.72 per cent
Acid insoluble ash .....	0.48 per cent	0.52 per cent

The quality of the flowers was raised by removing the chaff in screening. This screened material was used in all tests reported in this paper.

If sieves were used to separate the powder into samples of different degrees of fineness, the finer samples would contain a higher percentage of pyrethrins due to the fact that the seed achenes would be in those samples. Gnadinger and Corl (6) found the seed achenes to contain 92.4 per cent. of the total pyrethrins in the flowers.



Upon consideration of the above facts, it was decided to divide the ground flowers into a number of equal portions and regrind these samples in the ball mill for different lengths of time.

Photomicrographs were made of these different grinds when spread on plates in a film approaching one particle in thickness. These pictures (shown in plates X and XI under two magnifications) show the difference in particle size produced by the different lengths of grinding. The appearance of the clear, sharp-edged particles should be noted for another series of the same grinds coated with titanium dioxide was also made. The distinguishing feature of the second series is the white fringed appearance of the particles.

#### *Preparation of Protected Powders*

Fifteen per cent of  $\text{TiO}_2$  was mixed roughly with the ground pyrethrum. The mixture was then put through a corn mill twice, so as to give a uniform coating of the particles. This mill was so constructed that the shearing motion of the plates could be adjusted to give very little grinding of the pyrethrum flowers. Microscopic examination showed a very uniform coating of the particles after two passages through the mill (see plates XI and XII).

In preparing the pyrethrum powder protected with an antioxidant, a mixture consisting of 50 per cent tannic acid crystals dissolved in methyl cellosolve (ethylene glycol-mono-methyl ether) was prepared and allowed to stand overnight. Ten per cent of this 50-50 mixture was added to the ground pyrethrum and worked in thoroughly with a mortar and pestle. This gave a material consisting of 90 per cent pyrethrum flowers, 5.0 per cent tannic acid and 5.0 per cent methyl cellosolve. In commercial practice, this material could be diluted with acetone or some other solvent and sprayed into the dust.

#### *Methods and Equipment Used in Exposing Pyrethrum to Light*

The source of light was an Uviarc Mercury Vapor outfit designed for operation on alternating current. The voltage was adjustable by resistances, and was run on a line carrying 118 volts. The lamp current was 4.8 amperes and the wattage 450.

It is simple to operate, and requires no complicated radiating fins to control its temperature. It provides a standard light source of great intensity. An exposure of 1 hour to this light is equivalent in its effect on pyrethrum powder to a full day of bright June sunlight. In other words, it is approximately 12 times as effective as the sun at this time of year in producing loss of toxicity in pyrethrum powder.

The table upon which exposures were to be made was inclined at an angle of  $3^{\circ}$  above the horizontal so as to parallel the light source which operates at that angle. The distance from the mercury arc to the table top was 20 inches. Material was not placed under the lamp for testing until the intensity of the light was constant, *i.e.*, until the mercury was completely vaporized in the arc and the liquid mercury driven back into the cathode end of the tube.

Eastman Kodak ( $3\frac{1}{2} \times 4''$ ) thin cover glasses for lantern slides were coated with the dusts for exposure. It was difficult to secure an even coat of the pyrethrum one particle in thickness on the clean glass inasmuch as the powders consisted of particles of different sizes. It was finally found that the best method was to coat the slides with a very thin, even layer of Nujol, and then to pour the dust material carefully over the slide. The excess dust was jarred off. Even after considerable practice about 15 to 20 per cent of the plates had to be discarded.

The thin layers of dust were examined by direct and reflected light and beneath an Ultramac microscope to make certain that the dust was evenly applied and of the required thickness. Weighings were made on all slides used in the first two series of tests and those slides which were not within 10 per cent of the mean were discarded. Only a few slides had to be discarded. The average weights of the dust films were 30 mg.

As a further check on the methods used, 40 slides were prepared without special attention to equality in thickness of films. The ten heaviest slides and the ten lightest slides were selected, exposed to the light and tested on aphids. No appreciable effect on the kill was secured though the difference between the weights of the two series was 20 per cent of the total weight.

Tests were also run against *Aphis rumicis* and against mosquito

larvæ to find out whether the oil film had any effect on toxicity. No appreciable difference could be detected between the dry materials and those which were dusted on an oiled slide.

#### METHODS OF BIOLOGICAL TESTING USED

In testing the pyrethrum flowers of different finenesses three methods were used. First, the time of 50 per cent paralysis of mosquito larvæ was determined; second, the mortality of *Aphis rumicis* was determined when the ground flowers were applied in water suspension; and third, the mortality to *Aphis rumicis* was determined when the ground flowers were used as a dust.

The first tests were conducted on mosquito larvæ. These larvæ were identified as the species *Culex quinquefasciatus* Say by Mr. Carl Ilg of this station. The egg boats were sent by mail from the U. S. Bureau of Entomology Station at Orlando, Florida. The method of rearing the larvae and conducting the tests was essentially the same as that used by Campbell (2).

The material to be tested was weighed out and diluted to the required volume and immediately poured over fourth instar larvæ from which all the water had been drawn off. All materials were tested simultaneously on larvæ from the same batch, and duplicates were run on each material. The larvæ were removed as soon as they showed definite sign of paralysis. In this way the time of 50 per cent paralysis was obtained.

The spray tests on *Aphis rumicis* were conducted as follows: 300 to 400 insects were used in each test. The dilutions were made immediately before spraying, and one-tenth of one per cent soap was added to give wetting without adding appreciable toxicity. The insects were sprayed under uniform pressure until the plants were thoroughly wet. Counts were made after 24 hours and dead, moribund, and alive were recorded.

The dust tests on *Aphis rumicis* were conducted as follows. Plants were selected whose leaves had just started to bend over. A modification of the apparatus used by Campbell and Filmer (1) for coating leaves with arsenicals was developed and proved very satisfactory for securing an even coating of dust on the insects and leaves. A charge of 0.4 g. was blown into the bell jar and the dust allowed to settle for 7 minutes. Practically all the

dust could be delivered in this manner. Those aphids which had fallen from the plant were carefully transferred to the paper with a camel's hair brush. Counts were made as above after 24 hours. The charge used was equivalent to 30 pounds per acre in a cloud one foot deep.

#### PRESENTATION OF DATA

As was pointed out in the introduction, the purpose of this investigation was to establish three relationships:— (1) between the fineness of pyrethrum powder and its toxicity to insects, (2) between the fineness of pyrethrum powder and its rate of deterioration when exposed to light and air, and (3) between the fineness of pyrethrum powder and the degree of protection from deterioration by light and air afforded by certain pigments and anti-oxidants.

Three different methods of biological testing were used in order to arrive at conclusions concerning the above relationships. The data presented are averages of 5 or more individual tests. It is not feasible to present all of these individual tests in this paper, but it was necessary to run them in order to insure sound conclusions.

The first method used was the determination of the 50 per cent paralytic point for mosquito larvæ. The fineness of the pyrethrum was varied only by increasing the time of grinding in the ball mill. The data in table I show the time of 50 per cent paralysis, for unexposed powder of different fineness, for exposed powder of different finenesses, and for exposed powder of different finenesses to which had been added a protective pigment.

The mortality to *Aphis rumicis* was determined when the materials were applied in water suspension. The data in table II are the average of 5 tests. Each test consisted of 300 to 400 insects. The data show the per cent kill for unexposed powder of different fineness, for exposed powder of different finenesses, and for exposed powder of different finenesses to which has been added either a protective pigment or an anti-oxidant.

The mortality to *Aphis rumicis* was also determined when the materials were applied as a dust. The data in Table III are the average of 5 tests. Each test consisted of 300 to 400 insects.



TABLE I  
TESTS ON MOSQUITO LARVÆ TO DETERMINE THE EFFECT OF PARTICLE SIZE OF PYRETHRUM POWDER ON RATE OF PARALYSIS OF THE LARVÆ, RATE OF DECOMPOSITION OF THE POWDER BY LIGHT AND AIR, AND DEGREE OF PROTECTION FROM DECOMPOSITION SECURED BY COATING THE POWDER WITH TITANIUM DIOXIDE

Treatment and Dilution	Hours Reground					
	2.5	5.0	10.0	20.0	30.0	
	Time of 50% Paralysis in Minutes					
<i>Series A</i>						
(a) Unexposed—no protectant ( $1-60 \times 10^6$ ) .....	277.0	72.0	35.5	15.0	10.5	
(b) “ “ ( $1-20 \times 10^6$ ) .....	10.5	8.0	6.0	3.0	1.75	
(c) 1.5 hours Exposure—no protectant ( $1-20 \times 10^6$ ) .....	17.0	57.5	399.0	*	*	
(d) 1.5 hours Exposure—15% $\text{TiO}_2$ ( $1-20 \times 10^6$ ) .....	13.0	12.75	10.0	8.5	7.0	
<i>Series B</i>						
(a) Unexposed—no protectant ( $1-20 \times 10^6$ ) .....	12.0	10.5	8.0	5.25	3.5	
(b) 2.0 hours Exposure—no protectant ( $1-20 \times 10^6$ ) .....	*	*	*	*	*	
(c) 2.0 hours Exposure—15% $\text{TiO}_2$ ( $1-20 \times 10^6$ ) .....	26.5	29.9	23.7	27.5	35.0	
<i>Series C</i>						
(a) Unexposed—no protectant ( $1-30 \times 10^6$ ) .....	145.0	41.0	22.0	10.5	7.0	
(b) 3.0 hours Exposure—no protectant ( $1-30 \times 10^6$ ) .....	*	*	*	*	*	
(c) 3.0 hours Exposure—15% $\text{TiO}_2$ ( $1-30 \times 10^6$ ) .....	*	*	*	*	*	

\* = no 50% paralytic point reached within 24 hours.

TABLE II

SUMMARY OF SPRAY TESTS ON *Aphis rumicis* TO DETERMINE THE EFFECT OF PARTICLE SIZE OF PYRETHRUM POWDER ON MORTALITY TO APHIS, RATE OF DECOMPOSITION OF THE POWDER BY LIGHT AND AIR, AND DEGREE OF PROTECTION FROM DECOMPOSITION SECURED BY ADDING TITANIUM DIOXIDE OR TANNIC ACID

Treatment, Dilution and Exposure	Hours Reground				
	2.5	5.0	10.0	20.0	30.0
	% Kill of <i>Aphis rumicis</i>				
Unexposed—no protectant (1-30,000 + 0.1% soap)					
Series 1 .....	43%	44%	61%	63%	71%
Series 2 .....	66%	69%	76%	78%	82%
Series 3 .....	53%	55%	59%	62%	64%
Series 4 .....	63%	64%	68%	70%	77%
Exposed—no protectant (1-30,000 + 0.1% soap)					
Series 1 = 1.5 hours .....	39%	32%	21%	22%	20%
Series 2 = 1.5 hours .....	33%	30%	28%	24%	26%
Series 3 = 1.5 hours .....	38%	30%	26%	23%	20%
Series 4 = 3.0 hours .....	31%	28%	28%	23%	22%
Exposed—15% Titanium Dioxide (1-30,000 + 0.1% soap)					
Series 2 = 1.5 hours .....	66%	58%	55%	66%	71%
Exposed—5% Tannic Acid (1-30,000 + 0.1% soap)					
Series 3 = 1.5 hours .....	51%	53%	61%	62%	63%
Series 4 = 3.0 hours .....	48%	58%	51%	36%	37%

The data show the per cent kill for unexposed powder of different finenesses, for exposed powder of different finenesses, and for exposed powder of different fineness to which has been added either a protective pigment or an anti-oxidant.

#### DISCUSSION AND INTERPRETATION OF RESULTS

##### *Part I. The Effect of Particle Size of Pyrethrum Powder on Toxicity to Insects*

The data show that there is a very remarkable decrease in the time required for paralysis of 50 per cent of *Culex quinque-*

TABLE III

SUMMARY OF DUST TESTS ON *Aphis rumicis* TO DETERMINE THE EFFECT OF PARTICLE SIZE OF PYRETHRUM POWDER ON MORTALITY TO APHIS, RATE OF DECOMPOSITION OF THE POWDER BY LIGHT AND AIR, AND DEGREE OF PROTECTION FROM DECOMPOSITION SECURED BY ADDING TITANIUM DIOXIDE OR TANNIC ACID

Treatment and Exposure	Hours Reground				
	2.5	5.0	10.0	20.0	30.0
	% Kill of <i>Aphis rumicis</i>				
Unexposed—no protectant					
Series 1 .....	73%	76%	80%	83%	84%
Series 2 .....	68%	74%	79%	79%	86%
Series 3 .....	56%	59%	62%	67%	68%
Exposed—no protectant					
Series 1 = 1 hour .....	38%	32%	30%	23%	29%
Series 2 = 1.5 hours .....	22%	19%	15%	15%	14%
Series 3 = 1.5 hours .....	42%	27%	24%	21%	21%
Exposed—15% Titanium Dioxide					
Series 1 = 1 hour .....	72%	82%	83%	84%	85%
Series 2 = 1.5 hours .....	67%	62%	66%	69%	74%
Exposed—5% Tannic acid					
Series 3 = 1.5 hours .....	53%	54%	54%	55%	58%

*fasciatus* larvæ as the particle size of the powder decreases. Examination of the data (Table I, Series A, Test (a)) shows that the finest material gave 50 per cent paralysis in 10.5 minutes whereas the coarsest material tested gave the same result in 277.0 minutes. Another test (Series C, Test (a)) shows a range of 7.0 minutes to 145.0 minutes between the finest and coarsest materials.

The explanation for this relationship follows. Pyrethrins are only very slightly soluble in water, but they are extracted by water and form a colloidal suspension. Therefore, the greater the surface of the pyrethrum powder exposed to the water the more rapid is the dispersion of the pyrethrins. The mosquito larva is very susceptible to pyrethrins even in extremely low concentrations, and hence, is a very sensitive indicator of the rapidity of this extraction.

The variation in mortality to *Aphis rumicis* secured with the water suspensions of the unexposed pyrethrum of different finenesses was not as marked as the paralytic effect on mosquito larvæ. This is because the aphid is harder to kill and not affected by such small quantities of pyrethrins as the mosquito larva.

However, the kills obtained with the coarsest material and the finest material were as follows 43 per cent and 71 per cent, 66 per cent and 82 per cent, 63 per cent and 77 per cent. (See the unexposed materials Table II). These differences of 14 to 28 per cent are significant, especially when one considers that they are averages of 5 tests. Individual tests showed a range of as much as 35 per cent between the 2.5 and 30 hour grinds.

Since the water suspensions of the dusts were made up just previous to spraying, the same explanation applies here as was given for the quicker paralytic effects on mosquito larvæ. That is, the plant cells were broken up small enough in the longer periods of grinding to make the dispersion of pyrethrins more rapid.

When the pyrethrum powder of different finenesses was tested as a dust, the variation in mortality was of the same order as that found when the materials were applied in water suspension. The kills obtained with the coarsest and finest materials were as follows:— 73 per cent and 84 per cent, 68 and 86 per cent, 56 per cent and 68 per cent. (See unexposed material Table III.) As was pointed out above, these differences are significant as each figure is the average of 5 tests.

In explanation of these results with dusts, it is necessary to discuss briefly the method by which pyrethrum dust is believed to kill insects. Ginsburg (3) has shown that the toxic principles of pyrethrum are not volatile. Shafer (13) traced the entrance of dust materials into the spiracles by adding dye to the powder. The material did not penetrate very far into the trachea. Thus, the pyrethrins must be taken into the insect's body in solution. The solution is probably effected by the moisture and body exudate occurring on the insect's integument. The pyrethrins then gain entrance in solution through the integument or sensory pores on the insect's body. Hartzell and Wilcoxin (8) showed that concentrated oleoresin of pyrethrins entered the insect's



body through the integument. Tischler (unpublished data) showed that pyrethrum and derris dust affected the insect by passing directly through the integument.

*Part II. The Effect of Particle Size of Pyrethrum Powder on the Loss of Toxicity When Exposed to Light and Air*

The data show that, when pyrethrum powder is exposed to light from the mercury vapor lamp in air, the finer the particle size the more rapid is the decomposition produced. Examination of the data (Table I, Series A, Test (c)) shows that the time of 50 per cent paralysis was 17.0 minutes for the coarsest material after 1.5 hours exposure whereas with the two finest grinds the 50 per cent point had not been reached in 24 hours. With the unexposed material in this same series (Test (b)) the coarsest material gave 50 per cent paralysis in 10.5 minutes and the finest material gave 50 per cent paralysis in 1.75 minutes. An exposure of 2.0 hours completely destroyed the toxicity of all the materials tested, both coarse and fine.

Spray and dust tests on *Aphis rumicis* also showed the same result. That is, the finer particles were less toxic after exposure than the coarser materials. The data in Table II (Spray Tests—1.5 hours exposure) show kills ranging from 31–39 per cent in four series of tests with the coarsest material, while with the finest material in these same tests the kills ranged from 20–26 per cent. The data in Table III (Dust Tests—1.5 hours exposure) show kills ranging from 22–42 per cent for the coarsest material and 14 to 21 per cent for the finest material. When one considers the fact that before exposure the finer materials gave much higher kills than the coarser materials, these results are further accentuated. Thus, in two tests when the coarsest materials showed a drop of 4 to 14 per cent the finest materials showed a drop of from 47 to 55 per cent.

This toxicity data on aphids together with the paralytic tests on mosquito larvæ seem to show that with limited exposure the pyrethrins are protected somewhat from decomposition by light in the coarser material because they are in the unbroken cell.

*Part III. The Effect of Treating Pyrethrum Powder with Titanium Dioxide or Tannic Acid in Retarding Loss of Toxicity Upon Exposure to Light and Air*

The decomposition of pyrethrins by light from the mercury vapor lamp in air can be retarded for a limited time by the addition of titanium dioxide or of tannic acid. Unprotected material exposed for the same length of time loses 60–70 per cent of its toxicity. Even with the protectant added, the finer particles lose their toxicity more rapidly than the coarser ones, but the ratio is not as great as with the unprotected material.

The data in Table I (see Series A, (b, c, d)), show that pyrethrum powder coated with titanium dioxide lost very little of its toxicity when exposed to light for 1.5 hours. The untreated pyrethrum powder lost its toxicity and required a much longer time to reach a paralytic point of 50 per cent. In the 20 and 30 hour grinds it had not been reached at the end of 24 hours.

The pyrethrum powder not coated with  $\text{TiO}_2$  and not exposed to light produced 50 per cent paralysis of mosquito larvæ in 12 minutes for the coarser to 3.5 minutes for the finer powder (see Series B). The powder not coated with  $\text{TiO}_2$  but exposed for 2 hours to the light did not give 50 per cent paralysis with any of the materials at the end of 24 hours. On the other hand, powders ground for the same lengths of time, coated with 15 per cent  $\text{TiO}_2$  and exposed to light for 2 hours gave 50 per cent paralysis in 26.5 minutes for the coarser grinds to 35 minutes for the finer grinds.

When the materials were exposed for 3 hours (See Series C), toxicity was destroyed in both the untreated material and in the material coated with  $\text{TiO}_2$ . This shows that there is a gradual loss of toxicity in pyrethrum powder treated with  $\text{TiO}_2$ , and that the protective action does extend for more than 3 hours exposure to the mercury vapor lamp.

Spray tests on *Aphis rumicis* (Table II, Series 2) show that with 1.5 hours exposure the lowering in kill ranged from 34–54 per cent with the untreated materials whereas, with the materials coated with  $\text{TiO}_2$  it ranged from 1 to 20 per cent with an average lowering of 10 per cent.

When tannic acid was used as a protectant, no lowering in kill was observed after an exposure of 1.5 hours while the unprotected

material showed a drop of 14 to 46 per cent. With a 3 hour exposure the protection afforded by the tannic acid was beginning to decrease rapidly. It has been found by Moureu and Dufraisse (10) and other workers that a material which acts as an anti-oxidant may upon continued exposure or changed conditions act as a pro-oxidant and actually hasten the reaction which is had been retarding. This appears to be the case in the above experiments. When titanium dioxide was used, a gradual loss in toxicity was observed probably because the particles were not entirely coated with the pigment or because the pigment did not exclude all the injurious wave lengths of light.

Dust tests gave a duplication of the results of the spray tests on aphids. With an exposure of 1 hour there was a range in kill of 23-38 per cent for the unprotected material, and a range of 72 to 85 per cent for the material coated with  $\text{TiO}_2$ . The unexposed material ranged from 73-85 per cent. Thus, for this period of exposure the  $\text{TiO}_2$  had prevented a decomposition which otherwise would have amounted to 60 per cent. (See Table III.)

With 1.5 hours exposure, the range in kill for the unprotected material was 13 to 21 per cent, and 62 to 74 per cent for the material coated with  $\text{TiO}_2$ . The unexposed material gave kills ranging from 67 to 86 per cent. This shows a lowering of 5 to 10 per cent in the material protected with  $\text{TiO}_2$  against a lowering of 46 to 72 per cent in the unprotected material. Material protected with tannic acid showed only 4 to 10 per cent drop in kill after an exposure of 1.5 hours (see Table III).

#### SUMMARY

The following general conclusions may be drawn from the data presented:

(1) The finer the pyrethrum powder is ground the more rapid is the rate of paralysis of mosquito larvæ and the speed of kill of *Aphis rumicis*. The tests on aphids were conducted both as sprays and dusts with duplication of results. It appears that in each case the determining factor is the surface area of the ground particles exposed to the extracting medium.

(2) Secondly, paralytic and mortality tests conducted as above showed that the finer the pyrethrum is ground the more rapid is

the deterioration of the toxic principles upon exposure to light. Thus, the increase in surface area exposed to the light causes a quicker destruction of the pyrethrins.

(3) It would appear at first sight that the advantage of quicker kill secured by finer grinding is more than offset by the greater destruction of the toxic principles upon exposure to light in air. Data is presented, however, which shows that the deterioration of pyrethrum by light can be prevented for a limited time by either tannic acid, an anti-oxidant, or titanium dioxide, a pigment which reflects or absorbs the injurious wave lengths of light. The degree of protection secured does not vary with the different finenesses of pyrethrum powder.

(4) Even when the protectants are present, the pyrethrum powder begins to lose toxicity after a certain length of exposure. The material containing titanium dioxide holds its toxicity slightly longer than that containing tannic acid.

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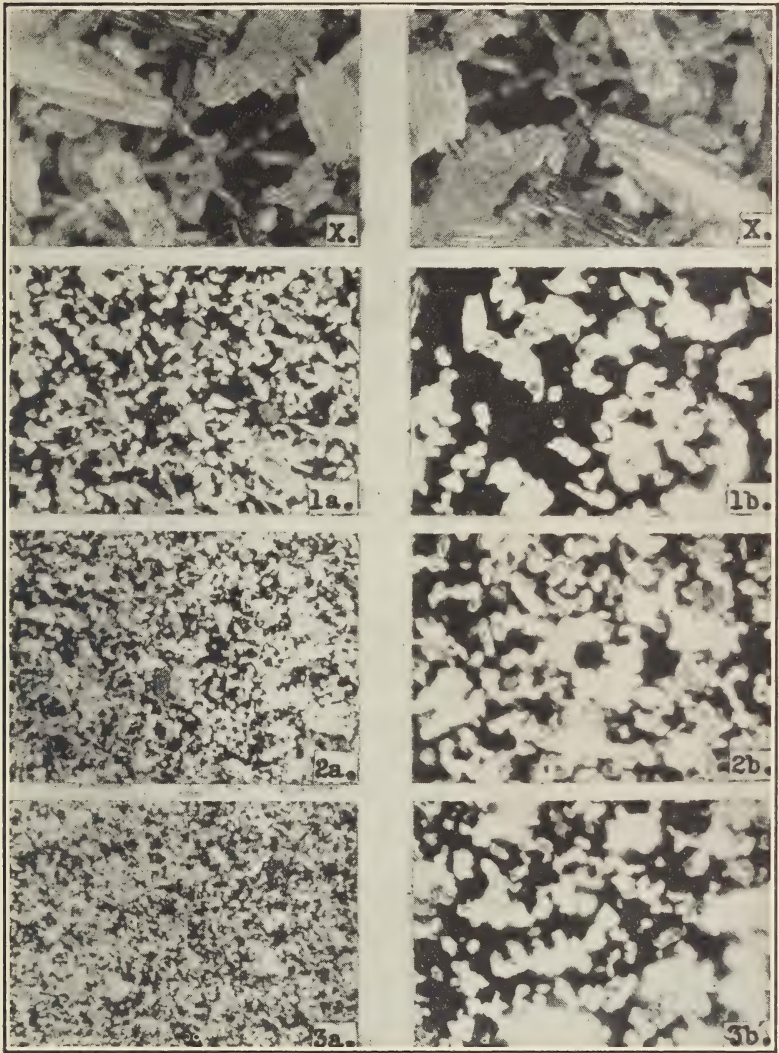
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## PLATE X

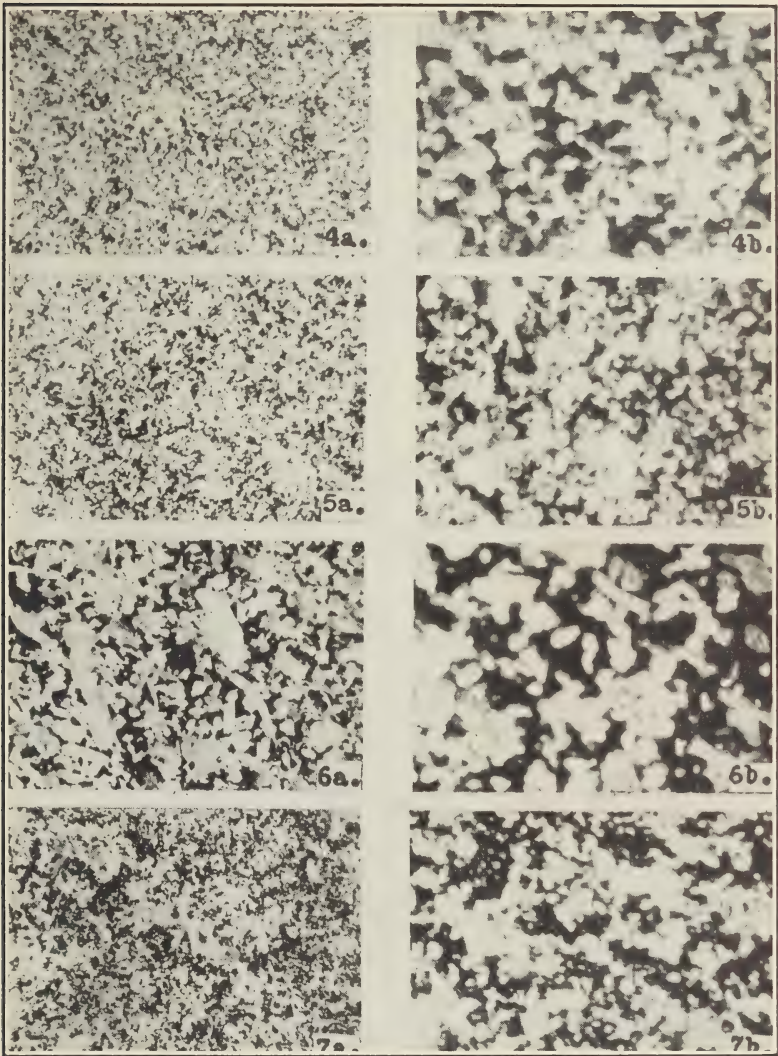
- Figure X. Pyrethrum flowers ground for percolation ( $\times 52.0$ ).  
Figure 1a. Pyrethrum powder reground 2.5 hours ( $\times 52.0$ ).  
Figure 1b. Pyrethrum powder reground 2.5 hours ( $\times 176.0$ ).  
Figure 2a. Pyrethrum powder reground 5.0 hours ( $\times 52.0$ ).  
Figure 2b. Pyrethrum powder reground 5.0 hours ( $\times 176.0$ ).  
Figure 3a. Pyrethrum powder reground 10.0 hours ( $\times 52.0$ ).  
Figure 3b. Pyrethrum powder reground 10.0 hours ( $\times 176.0$ ).



## PLATE XI

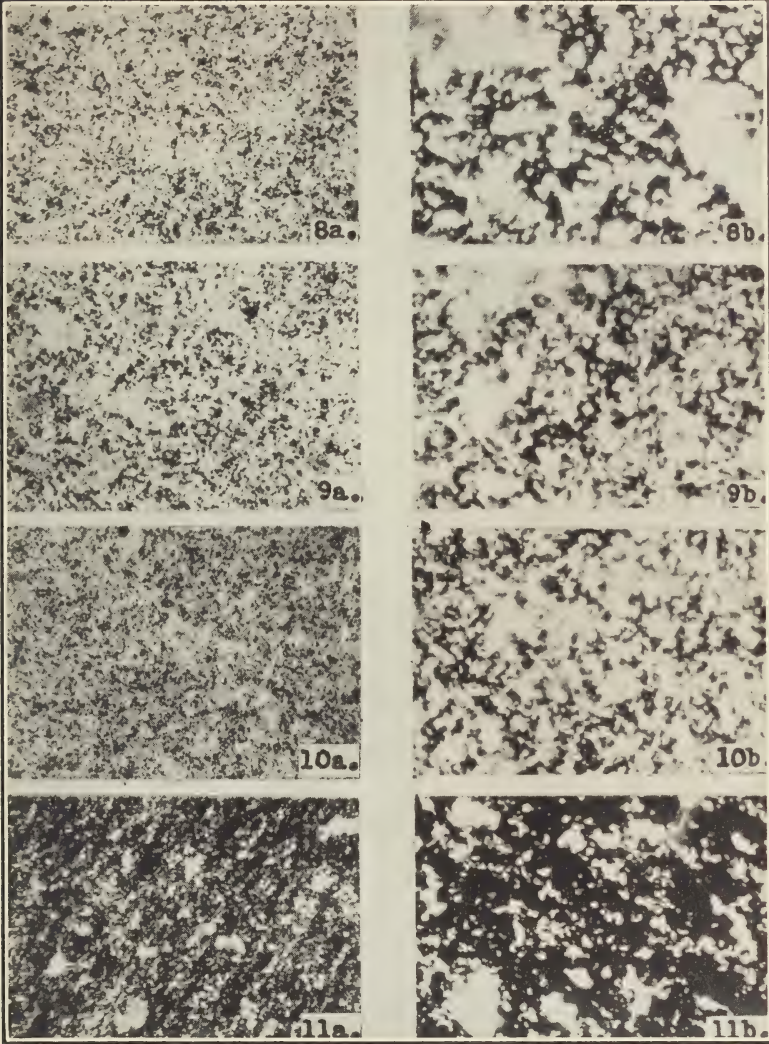
- Figure 4a. Pyrethrum powder reground 20.0 hours ( $\times 52.0$ ).  
Figure 4b. Pyrethrum powder reground 20.0 hours ( $\times 176.0$ ).  
Figure 5a. Pyrethrum powder reground 30.0 hours ( $\times 52.0$ ).  
Figure 5b. Pyrethrum powder reground 30.0 hours ( $\times 176.0$ ).  
Figure 6a. Pyrethrum powder reground 2.5 hours coated with  $\text{TiO}_2$  ( $\times 52.0$ ).  
For same material without pigment see Figure 1a, Plate X.  
Figure 6b. Pyrethrum powder reground 2.5 hours coated with  $\text{TiO}_2$  ( $\times 176.0$ ). For same material without pigment see Figure 1b, Plate X.  
Figure 7a. Pyrethrum powder reground 5.0 hours coated with  $\text{TiO}_2$  ( $\times 52.0$ ).  
For same material without pigment see Figure 2a, Plate X.  
Figure 7b. Pyrethrum powder reground 5.0 hours coated with  $\text{TiO}_2$  ( $\times 176.0$ ). For same material without pigment see Figure 2b, Plate X.





## PLATE XII

- Figure 8a. Pyrethrum powder reground 10.0 hours coated with  $\text{TiO}_2$  ( $\times 52.0$ ). For same material without pigment see Figure 3a, Plate X.
- Figure 8b. Pyrethrum powder reground 10.0 hours coated with  $\text{TiO}_2$  ( $\times 176.0$ ). For same material without pigment see Figure 3b, Plate X.
- Figure 9a. Pyrethrum powder reground 20.0 hours coated with  $\text{TiO}_2$  ( $\times 52.0$ ). For same material without pigment see Figure 4a, Plate XI.
- Figure 9b. Pyrethrum powder reground 20.0 hours coated with  $\text{TiO}_2$  ( $\times 176.0$ ). For same material without pigment see Figure 4b, Plate XI.
- Figure 10a. Pyrethrum powder reground 30.0 hours coated with  $\text{TiO}_2$  ( $\times 52.0$ ). For same material without pigment see Figure 5a, Plate XI.
- Figure 10b. Pyrethrum powder reground 30.0 hours coated with  $\text{TiO}_2$  ( $\times 176.0$ ). For same material without pigment see Figure 5b, Plate XI.
- Figure 11a. Titanium dioxide pigment ( $\times 52.0$ ).
- Figure 11b. Titanium dioxide pigment ( $\times 176.0$ ).







## NEW SPECIES AND RECORDS OF COLORADO DIPTERA

BY MAURICE T. JAMES

COLORADO STATE COLLEGE

Collectors from the outside who have visited Colorado in the past have, to a great extent, neglected one of the most interesting regions of the state, namely, the short-grass plains of the eastern counties. Characteristic as the mountain faunas are, they do not contain everything of entomological interest that Colorado has to offer. The eastern plains, forming what the plant ecologists of the Weaver-Clements school call the *Bulbilis-Bouteloua* associates, have a distinctive dipterous fauna which to a great extent, consists of elements entering from the east, but which, especially in sand-hills areas, contains certain southern and southwestern constituents.

In the accompanying paper, certain new state records are given, and several new species described, all but one from the short-grass region.

### THEREVIDÆ

#### *Psilocephala pavid*a Coquillett

2 males, Roggen, Colorado, May 19, 1934 (M. T. James).

This species, described from Los Angeles County, California, is recorded by Cole only from Southern California. The two specimens above mentioned agree perfectly with Coquillett's and Cole's descriptions, and Cole's illustrations. They were taken in the sand-hills area, however, which has many southern and southwestern constituents included in its fauna.

#### *Psilocephala coloradensis*, new species

Related to *P. frontalis* Cole, *P. hæmorrhoidalis* Macquart, and *P. albertensis* Cole; the wholly black anterior tibiæ will distinguish it from those species. The male genitalia are entirely and moderately densely black-pilose, as in *hæmorrhoidalis*, but the frontal pollinose markings, in both sexes, resemble those of *frontalis*. The wings are rather heavily but uniformly infumated; this, together with the greater amount of pale on the legs, will distinguish it from *costalis* Loew.

MALE. Body entirely black in ground color. Head covered with whitish pollen, except a small area on each cheek and the large frontal prominence, the latter shining black. Pile of face and of lower part of occiput whitish and rather fine, except for an area of coarse, short, black pile on each cheek; pile of front and ocellar triangle black, rather coarse; bristles of occiput black. Antennæ black; the first and second segments clothed with moderately long black bristles; the third segment on the basal fourth with shorter black bristles which are densest above; the third segment about equal in length to the first two combined, the style somewhat shorter than the second segment. Thorax whitish pollinose and whitish pilose, with black bristles; in well-preserved specimens, there is a considerable amount of black pile mixed with the white pile of the dorsum. Halteres black. Scutellum with four black marginal bristles. Abdomen densely whitish pollinose, silvery dorsally; the very narrow apices of segments 2 and 3 white; the basal lateral angles of segments 2-5 inclusively, segment seven, and genitalia, shining black; genitalia wholly black-pilose, the pile rather conspicuous; also some black pile ventrally on segments 5-7 inclusively. Femora black, with white pile and black bristles; tibiae and tarsi with short stubby black pile and black bristles; anterior tibiae and tarsi wholly black; middle and hind tibiae and basitarsi yellow, with narrow black apices, broader proportionally on the tarsi; tarsi otherwise black, with at most a small amount of yellow at the base of the second segment. Wings rather uniformly infumated, slightly more heavily so near the costa, at the apex, and along the veins bordering the discal cell; origin of vein  $R_{2+3}$  remote from the discal cell; fourth posterior and anal cells closed and petiolate; length, 7-8 mm.

FEMALE. Similar to the male; the front with a short pollinose area extending upward along each eye from the pollinose facial region; a similar pollinose spot to each side of the ocellar triangle; the inner ocular orbits are very narrowly pollinose. Pile of body sparser than in the male. Thorax only very indistinctly vittate; no black thoracic pile. Pile of abdominal segments 4-8 inclusively with short, stubby black pile, ventrally and dorsally.

Holotype: male, Boulder, Colo., May 24, 1934. (A. L. Hays.)

Allotopotype: female, Boulder, Colo., Aug. 3, 1932 (M. T. James.)

Paratypes: 6 males, 7 females, Boulder, Colo., June 3, 9, 10, July 7, 1932 (James), June 9, 13, 25, 28, 1933 (James), June 8, 1934 (James); 1 female, Boulder, Colo., June 5, 1927 (E. C. Nelson); 4 females, Olney Springs, Colo., May 28 and Sept. 1, 1932 (James); 3 males, Crowley, Colo., Sept. 1, 1932 (James); 2 males, 1 female, Roggen, Colo., July 31, 1934, and Sept. 8, 1933 (James); 3 females, 1 male, White Rocks, near Valmont, Colo., July 2 and 4, 1933 (M. T. and H. B. James); 1 female, south of Coolidge, Kans., July 31, 1933 (H. G. Rodeck and M. T. James); 1 female,

1 male, Two Buttes, Colo., Aug. 1, 1933 (Rodeck, James); 1 male, North of Cheyenne Wells, Colo., July 27, 1933 (Rodeck and James); 1 male, east of Burlington, Colo., July 26, 1933 (Rodeck and James); 1 male, Cimarron River, north of Ramsey, Okla., Aug. 3, 1933 (Rodeck and James); 1 female, Ft. Collins, Colo., June 11, 1934 (Kenneth Maehler).

This species, apparently common in the grassland area of eastern Colorado, has been taken in association with *P. platancala* Loew at Boulder and Roggen. The latter species seems more characteristic of the higher altitudes. Both species seem to occur in medium or mixed grassland societies in the short grass plains region. The paratype localities of Kansas and Oklahoma are, in each case, within a mile of the Colorado line.

#### RHAGIONIDÆ

##### *Chrysopilus aldrichi*, new species

Related to *C. flavibarbis* Adams, of which it may be merely a subspecies or high altitude race. It is, however, considerably more robust; the thorax, from wing-base to wing-base, is as broad as its length, including the scutellum, whereas in *flavibarbis* the thorax is more slender; the head and abdomen are of proportionate breadth. Perhaps the best distinguishing character is the vestiture of the palpi, which is coarse and black. Runs to *flavibarbis* in Leonard's key.

Holotype: Male, Tolland, Colo., July 10, 1932 (M. T. James).

Allotype: Female, Long's Peak Inn, Canadian Zone, July 21 (T. D. A. Cockerell) (determination label, "*Chrysopilus* n. sp. ? det. Aldrich").

Paratypes: Female, A. S. U. C. Lodge, 7800 ft. near Boulder, Colorado, July 1, 1932 (James); 2 males, Gold Hill, Colo., 8000 ft., June 24, 1932 (James).

##### *Chrysopilus arctiventris* new species

A slender species, resembling in form the European *C. aureus*; in Leonard's key it runs (rather imperfectly, since the femora have a considerable amount of yellow on them) to *proximus* Walker, but it is quite a different species.

MALE. Head, thorax including coxæ, and abdomen black in ground color, but densely whitish-pollinose, the pollen entirely concealing the ground color; on the bases of abdominal segments 2-7 inclusively the pollen becomes gradually brownish, and is definitely brown on the basal third of the segments. Antennæ black, the three segments subequal to each other, but the third slightly the longest and the first the shortest; arista twice as long as the

three segments combined; first segment distinctly white-pilose below, the other segments white-pubescent. Palpi long, slender, black; proboscis yellow; palpi proboscis face, cheeks, and occiput with rather long but moderately sparse white pile. Thorax and abdomen rather sparingly clothed with whitish pile and pale-yellow scale-like tomentum, the pile densest on the coxæ, halteres yellow, their knobs black. Femora blackish with whitish scale-like tomentum above and short white pile below; the apices, the basal third of the middle and the basal half of the hind femora, yellowish; hind femora clavate and longer than the others; tibiæ yellow; tarsi blackened, except the basal part of the basitarsi. Wings hyaline, the stigma pale brown; veins  $M_1$  and  $M_2$  arise from the discal cell very close to each other, though the paratypes show considerable latitude here. Length, 7 mm.

FEMALE. Similar to the male; the upper front and the vertex are brown-pollinose, and the posterior femora are yellow; other legs missing in the type.

Holotype: Male, Roggen, Colo., May 19, 1934 (M. and H. James).

Allotopotype: Female, same data.

Paratopotypes: 2 males, same data; 1 male, May 19, 1934 (Sybil D. Grow).

From the sand-hills region; taken in a stream-side sedge-cat-tail community.

#### ASILIDÆ

##### *Stichopogon argenteus* Say

This is apparently a sand-inhabiting species. It has been recorded on sandy beaches along the Atlantic coast, and again in California. My inland records are unique, but I can not distinguish my specimens from eastern ones. I have taken it resting directly on the sand at Roggen, Sept. 8, 1932; also at the foot of the Alamosa Sand Dunes, Sept. 1, 1934.



## AN INTERNAL STRUCTURE IN THE CYRTACANTHACRINÆ (ORTHOPTERA, ACRIDIDÆ) OF POSSIBLE TAXONOMIC VALUE.

BY ELEANOR H. SLIFER AND ROBERT L. KING  
DEPARTMENT OF ZOOLOGY, STATE UNIVERSITY OF IOWA

In 1899 Comstock and Kellogg described rounded pouches of a reddish color lying on either side of the vagina (median oviduct) in *Melanoplus femur-rubrum*. These pouches, they stated, open below the ventral valves of the ovipositor and in fresh specimens can be everted by pressure. Comstock and Kellogg did not determine their function but suggested that they might be glandular. A few years ago Vardé (1929, 1934), unaware of the earlier report of Comstock and Kellogg, described these same structures more completely in *Anacridium ægyptium*, *Calliptamus italicus*, *Pezotettix giornæ*, *Schistocerca paranensis*, *Schistocerca gregaria*, *Patanga succincta*, *Palaciosia khandalensis* and a species of *Podisma*, and suggested that the pouches may be a distinct subfamily characteristic. Snodgrass (1935) has since noted the presence of these organs in *Melanoplus* and has pictured them for *Melanoplus femur-rubrum*. He mentions the 1929 paper of Vardé but does not refer to Comstock and Kellogg.

Vardé devised the name oviducal vesicles (vésicules oviducalaires) for these structures because of their proximity to the oviduct. This name is not particularly appropriate since it suggests that they are a part of the oviduct whereas actually they are quite distinct from it.

During the present study fifty-five species of Acrididæ, belonging to four subfamilies, have been examined, as follows:

### Acridinæ

<i>Ageneotettix deorum</i>	<i>Mermiria neomexicana</i> *
<i>Chloealtis conspersa</i> *	<i>Opeia obscura</i> *
<i>Chorthippus longicornis</i> *	<i>Orphulella speciosa</i> *
<i>Dichromorphia viridis</i>	<i>Pseudopomala brachyptera</i> *
<i>Eritettix simplex simplex</i> *	<i>Syrbula admirabilis</i>
<i>Mermiria maculipennis mac-</i>	
<i>clungi</i> *	

## Oedipodinæ

<i>Arphia pseudonietana</i> *	<i>Pardalophora haldemanii</i> *
<i>Arphia sulphurea</i>	<i>Psinidia fenestralis fenestralis</i>
<i>Arphia xanthoptera</i>	<i>Scirtetica marmorata marmorata</i>
<i>Camnula pellucida</i> *	<i>Spharagemon bolli</i>
<i>Chortophaga viridifasciata</i> *	<i>Trimerotropis citrina</i> *
<i>Dissosteira carolina</i>	<i>Trimerotropis maritima maritima</i>
<i>Encoptolophus sordidus</i>	<i>Trachyrhachis kiowa fuscifrons</i> *
<i>Hadrotettix trifasciatus</i>	<i>Trachyrhachis kiowa kiowa</i> *
<i>Hippiscus rugosus</i>	
<i>Pardalophora apiculata</i> *	

Pyrgomorphinæ<sup>1</sup>

<i>Ichthydion mexicanum</i> *	<i>Sphenarium sp.</i> *
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## Cyrtacanthacrinæ

<i>Campylacantha olivacea olivacea</i>	<i>Melanoplus gracilis</i> *
<i>Hesperotettix viridis pratensis</i> *	<i>Melanoplus keeleri luridus</i>
<i>Hypochlora alba</i>	<i>Melanoplus mexicanus mexicanus</i>
<i>Melanoplus angustipennis</i>	<i>Melanoplus packardii</i> *
<i>Melanoplus bivittatus</i>	<i>Melanoplus scudderi scudderi</i>
<i>Melanoplus confusus</i> *	<i>Melanoplus viridipes viridipes</i> *
<i>Melanoplus dawsoni</i> *	<i>Melanoplus walshii</i>
<i>Melanoplus differentialis</i>	<i>Paroxya sp.</i> *
<i>Melanoplus femur-rubrum rubrum</i>	<i>Phætalioles nebrascensis</i>
<i>Melanoplus flavidus flavidus</i>	<i>Romalea microptera</i>
<i>Melanoplus fædus fluvialis</i>	<i>Schistocerca alutacea</i>
<i>Melanoplus gladstoni</i>	<i>Schistocerca americana americana</i>

The glandular pouches of Comstock and Kellogg have been found to be present in all members of the Cyrtacanthacrinæ listed above and absent in all species of the other three subfamilies.

In most of the grasshoppers which possess them the pouches are conspicuous because of the pigment which they contain. The color observed immediately after the abdomen had been opened is given below for a number of species.

The pouches of four species—*Melanoplus differentialis*, *Romalea microptera*, *Schistocerca alutacea* and *Schistocerca*

<sup>1</sup> Dr. Eleanor Carothers very kindly gave us specimens of this subfamily for examination.

SPECIES	COLOR OF GLANDULAR POUCHES IN LIVING CONDITION
<i>Campylacantha olivacea olivacea</i> .....	brown
<i>Hypochlora alba</i> .....	orange brown
<i>Melanoplus angustipennis</i> .....	nearly colorless
<i>Melanoplus bivittatus</i> .....	reddish brown
<i>Melanoplus differentialis</i> .....	red
<i>Melanoplus flavidus flavidus</i> .....	orange brown
<i>Melanoplus fædus fluviatilis</i> .....	light brown
<i>Melanoplus gladstoni</i> .....	dark red
<i>Melanoplus keeleri luridus</i> .....	brown
<i>Melanoplus mexicanus mexicanus</i> .....	light reddish brown
<i>Melanoplus scudderi scudderi</i> .....	light brown
<i>Melanoplus walshii</i> .....	light brown
<i>Phætaliothes nebrascensis</i> .....	brown
<i>Schistocerca alutacea</i> .....	light brown
<i>Schistocerca americana americana</i> .....	very light brown

*americana*—were studied cytologically. Various fixatives (Allen's, Bouin's, Carnoy-Lebrun, Champy and Helly's) and a number of different stains (Ehrlich's hematoxylin with triosin, Giemsa, Heidenhain's iron-hematoxylin and Mallory's connective tissue) were tried. Champy fixation followed by 2 per cent osmic acid was also used. The results confirmed Vardé's observations in all respects and need not be repeated here. One point, however, seems worth noting. With Giemsa the secretion mass in the lumen of the pouch is seen to consist of innumerable thread-like "casts" of the intracellular canaliculi embedded in a lighter-staining homogeneous matrix. With other stains this differentiation into two components was not apparent.

In the case of the species marked on the foregoing pages with an asterisk dried specimens instead of fresh were examined. This can be done very readily by removing the tip of the abdomen and allowing it to soak for several hours in a 25 per cent solution of KOH. The softened muscles, trachea, etc., can then be pulled out and, after repeated washings in water the preparation is ready for examination. If the pouches are found to be present they may be removed, slit open and examined microscopically. The

chitinous intima with the hundreds of minute canaliculi attached to, and which open through it can then be stained, dehydrated, cleared and mounted permanently if desired.

Vardé compares these pouches of the grasshopper to somewhat similar glands possessed by the *Bombyx mori* female. These are everted at the time of copulation and are thought to produce an odor attractive to the male. Those who handle grasshoppers in large numbers are sometimes aware of distinct odors produced by certain species. *Romalea microptera*, for example, gives off a strong odor which is noticeably unpleasant when the animals are confined in a small or poorly-ventilated container. It would be interesting to ascertain the source of this odor. Perhaps the glands of Comstock and Kellogg are responsible.

#### SUMMARY

Of fifty-five species of Acrididæ examined all of the Cyrtacanthacrinæ, but none of the Acridinæ, Oedipodinæ or Pyrgomorphinæ were found to possess the glandular pouches described in *Melanoplus femur-rubrum* by Comstock and Kellogg.

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## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF JANUARY 7, 1936

The annual meeting of the Society was held on January 7, 1936, in the American Museum of Natural History; President Schwarz in the chair with thirty-two members and forty visitors present.

Dr. Melander read the report of the Nominating Committee which was as follows:

*President:* Herbert Ruckes

*Vice-president:* C. Howard Curran

*Secretary:* Lucy W. Clausen

*Treasurer:* G. C. Hall

*Librarian:* F. E. Watson

*Curator:* A. J. Mutchler

*Executive Committee:* Wm. T. Davis, F. E. Lutz, E. L. Bell,  
Henry Bird, H. F. Schwarz

*Publication Committee:* Harry B. Weiss, John D. Sherman, Jr.,  
C. Howard Curran, H. T. Spieth

*Delegate to the New York Academy of Sciences:* W. T. Davis

Nominations were closed and the secretary was empowered to cast one ballot for the officers as nominated.

Mr. Schwartz then turned the meeting over to the new president, Dr. Ruckes.

Action on the amendment to the By-Laws authorizing the holding of but one meeting of the Society each month (excepting June, July, August and September) was taken. After some discussion the recommendation of the committee was voted down and it was decided that two meetings a month be retained, one an informal round table discussion, and the other the presentation of a formal paper.

A motion, made by Mr. Bell and seconded by Mr. Schwarz, that Mrs. Engelhardt, who had so capably filled the position of Secretary of the Society, be given a standing vote of thanks, was unanimously carried.

Dr. Ruckes showed his Greutz-ray photograph of a tropical roach known as "Archie." This enlargement was made by Mr. A. W. Fuchs, of the Eastman Kodak Co.

Mr. Davis accepted the invitation to take the leadership of the next meeting which would be in the form of an informal round table discussion.

The Program Committee announced that at the next formal meeting of the Society, on February 4, Dr. A. B. Klots would give an address on the "Butterfly Zoögeography in the Rocky Mts."

Dr. Ruckes then presented the speaker of the evening, Dr. Melander, who told of his travels in the western part of the country. On this trip Dr. Me-

lander used a trailer that was fitted with a laboratory as well as with comfortable living quarters. The talk was illustrated by slides and motion pictures, many of which were in color. When the colored pictures were shown Dr. Melander gave a short explanatory discussion on the principles of color photography. An English process, DuFay color, makes it possible, by a simple process, to reproduce a superior and faithful rendition of color. A German process, Agfa Color film, renders the picture in black and white in terms of color. Thus by placing a filter over the projector the hitherto black and white picture is portrayed in color.

Committees appointed by President Ruckes:

*Program Committee:* Dr. A. B. Klots, Dr. A. L. Melander, Wm. Kisliuk

*Auditing Committee:* Dr. Wm. Moore, Frank Johnson, Dr. Henry Fox

*Field Committee:* A. S. Nicolay, Herman Moennich

LUCY W. CLAUSEN, *Secretary.*

#### MEETING OF JANUARY 21, 1936

A regular meeting of the Society was held on January 21, 1936, in the American Museum of Natural History; President Ruckes presiding with twenty-one members and five visitors present.

Dr. Ruckes announced that at the next formal meeting of the Society Dr. Klots would give an address on "Butterfly Zoogeography in the Rocky Mountains."

Mr. Wm. T. Davis opened the evening's discussion by speaking about cicadas. The genus *Okanagana* is typically North American although several species were first described from Europe. Mr. Davis pointed out that in a series of *O. magnifica* in his collection an interesting supernumerary vein tends to appear in the region of the first cubitus, and that this variation is not limited to any one brood or specimens from any one locality. In discussing other genera the speaker pointed out that the phylogeny of the species is not as clearly defined as that for *Okanagana* and that more studies would have to be made before the relationship between species could be established.

There are several enemies of cicadas. The more important ones are the imported wasp, robbers flies, big spiders, *Polistes pallipes* which has been caught in the act of killing *Cicada hieroglyphica*, mutillids, and *Sphecius speciosus*. In discussing *Sphecius speciosus*, the large wasp which is usually called the Cicada-killer, Mr. Davis mentioned some of its interesting habits. It appears that during the breeding season males usually lie in ambush and await the passing of the females. A male then leaves his hideout, chases the female and, if successful, mating takes place on the wing. With examples of very fine specimens from his collection Mr. Davis illustrated the many points in his talk.

The discussion was participated in by Drs. Horsfall, Klotz and Wiegmann and Mr. Olsen and others.

Mr. Mutchler exhibited an interesting acquisition—a group of seven diminutive Mecoptera from Ohio. Until the members were told to what order these insects belonged they were puzzled.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF FEBRUARY 4, 1936

A regular meeting of the Society was held on February 4, 1936, in the American Museum of Natural History; President Ruckes presiding with sixteen members and eight visitors present.

Dr. Klots made a motion that a committee be appointed by the President to send condolences to Mrs. Benjamin upon the death of her husband, Mr. Benjamin, a lepidopterist of the National Museum. Dr. Ruckes appointed Mr. Schwarz and Dr. Klots to act on this committee.

Dr. Ruckes announced that at the next meeting Mr. Nicolay will lead an informal discussion with special emphasis on Coleoptera.

Dr. Klots then gave the address of the evening on "Butterfly Zoogeography in the Rocky Mountains." The two butterfly genera *Colias* and *Brenthis* present many zoogeographical problems in North America. Both are essentially Holarctic in distribution and presumably North America has been populated by them by means of southward dispersal of the species. It is evident that the majority of the species are well represented in both northern and southern regions by various races. Probably therefore some, at least, of the species which are thought to occur only in southern regions are really derivatives of others thought to occur in northern regions. Study of such "species" points out the probability of very close relationship between *B. chariclea* and *B. montinus*, so that the latter should be placed as a race of the former. Furthermore *B. helena* is very closely allied to *B. chariclea*, particularly closely through *B. chariclea rainieri* and not through *B. helena ingens* of Montana, so that it may be advisable to place *helena* as a race of *chariclea* likewise.

Similarly, a close relationship evidently exists between *C. christina* and *C. alexandra*; in the northern Basin and intermontane region these species are almost indistinguishable, but east of the Rocky Mountains in Wyoming and Montana they are very distinct. Probably *alexandra* spread southward through the Great Basin of Utah, around the southern end of the Rocky Mountain, and northward east of the Continental Divide; by the time it reached Wyoming and Montana, where *christina* occurred, it had differentiated greatly.

*C. scudderi*, usually considered as being limited to Colorado, shows considerable resemblance to *C. gigantea* which ranges from Hudson Bay to southern Canada, and also to *C. astraea*, which is known to range from north-central Canada to northern Wyoming; it is probably a southern derivative of one or the other of these species.

*C. harfordi* is probably descended from an isolated colony of *C. eurytheme* and is found only in the southern Sierras. *C. philodice* of northeastern

United States and southeastern Canada, is almost certainly merely a localized race descended from *eurytheme* stock.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF FEBRUARY 18, 1936

A regular meeting of the Society was held on February 18, 1936, in the Museum of Natural History; President Ruckes in the chair with nineteen members and eight visitors present.

Dr. Melander, Chairman of the Program Committee, announced that Mr. John D. Sherman, Jr., would speak at the March 3 meeting on "Comments and Stories about Entomological Books."

Mr. Schwarz presented a memorial report upon Mr. Benjamin's death to be sent to Mrs. Benjamin. The report follows:

Foster H. Benjamin, whose career of accomplishment seemed to give assurance of further goals to be attained, died in his forty-first year. To many members of the New York Entomological Society he was personally known and to these especially his untimely death has been a great shock, robbing them not only of a fellow worker of great promise but of one who had a hold upon their esteem and affection.

Because of his worth both as an entomologist and as a man, the New York Entomological Society desires to record its deep sense of loss in his death, and directs its secretary to send this expression of its heartfelt sympathy to his family.

Upon hearing that Mr. William T. Davis had suffered an injury that confined him to his home the Society sent to him the following letter, signed by all the members present at the meeting.

"The members of the New York Entomological Society having heard of your recent mishap extend to you their deepest sympathy and sincerely trust that you will have a speedy recovery and be with us again soon."

Mr. L. Marks of 1288 Adeo Ave., New York, was nominated by Dr. Ruckes to membership of the Society.

Mr. Nicolay told of his collecting on Mt. Desert Island last summer. As he spoke he passed many photographs around, giving the members an opportunity to better visualize his collecting grounds. He also showed a box of specimens. Mr. Nicolay told of his early collecting in Jamaica, L. I., East New York, and later in the Palisades. Each place was in its turn excellent hunting grounds until one by one they were abolished by city development. Greenwood Lake is about the only place still practically untouched, according to Mr. Nicolay.

Mr. Dietrich then spoke of his interest in *Melanotus*, using the genitalia as a basis of classification. He also described the condition in parks due to the excess cleaning and pruning that takes place. This kills off the live insects since they are deprived of suitable breeding and hiding places.

Dr. Fox showed maps on the latest distribution of the Japanese Beetle. He raised the question "How far does the physiology of native species account for its distribution in the field?"



Mr. Mutchler displayed a recently published book "Insect Enemies of Shade Trees" by Glenn Herrick, that he thought about as complete a book on the subject as ever printed.

Mr. Rau exhibited a cottony cushion scale found very abundantly in the Botanical Gardens.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF MARCH 3, 1936

A regular meeting of the Society was held on March 3, 1936, in the Museum of Natural History; President Ruckes in the chair with twenty-two members and eleven visitors present.

Dr. Melander announced that the next meeting would be devoted to notes by members.

Mr. L. Marks, of 1288 Adeo Ave., was duly elected to membership.

A note from Mr. Davis thanking the Society for its letter of sympathy was read by the secretary.

A letter from Mr. William Broadwell offering for sale his collection of Geometrids was also read.

Several deaths and illnesses were reported among the older members. The death of A. N. Caudell, an orthopterist of Washington, and L. B. Smith, formerly in charge of the Japanese Beetle Laboratory, were reported. Mr. Engelhardt and Dr. Spieth were appointed to send the regrets of the Society to Mrs. Caudell. Dr. Leonard was appointed to write a memorial letter to the family of L. B. Smith. Mr. Engelhardt told of the illness of Messrs. VanDuzee and Dow.

Dr. Ruckes then presented the speaker of the evening, Mr. Sherman. The importance and value—especially from a book collector's viewpoint—of FIRST BOOKS on any subject, or FIRST BOOKS of an author was cited as an elementary fact for book dealers. In no case is this more true than in the case of the first of all printed books—the Gutenberg Bible published (without date) 1451–1455. A copy of this book was purchased by Dr. Vollbehr for \$275,000—plus \$25,000 export tax.

Probably the third edition of Pliny's "Natural History" printed by the celebrated Jenson Press at Venice in 1474 is one of the most valuable of natural history books. Dr. Gudger wrote a paper on Pliny's work calling it the "most popular of all natural history books."

Mr. Sherman mentioned the purchase of the Blanchard library in 1914, shipped in sugar barrels, as his first venture in the book business. He referred to later purchases of spider books from a Washington dealer, the large Fernald library in 1929—from which the rarest book Clerck's "Icones," was sold to the A. M. N. H. library—the money coming from Mr. Morgan. One purchase that he never even saw was a set of "Genera Insectorum" bought in Cairo, and sold without the case having been opened.

Various auctions were referred to more or less "sub rosa" evidently without all the facts being revealed.

Entomological books have never reached very large sales. Of Reitter's "Fauna Germanica" in 5 volumes, in Europe, 70,000 copies were printed. In the U. S. A. about 25,000 copies of Holland's "Butterfly Book," of which the first edition appeared in 1898, have been sold, and of Lutz's "Hand Book," 17,000.

Some insect books have been remaindered, including even the original American stock of Imm's great textbook, of which Mr. Sherman bought the last 50 copies or so.

Stories of the fabulous prices eventually realized from Theodore Roosevelt's early pamphlets on birds were told, especially those about his earliest publication, a small "broadside."

Having started with the very first and most important of all books, Mr. Sherman ended with the most important of all Zoological books—Linné's "Systema Natura." The A. M. N. H. copy of the 1st (Folio) edition of the work published 1735–36 was exhibited as a loan out of the A. M. N. H. Library safe—under a bond of \$10,000.

From a strictly scientific viewpoint, however, it is the 10th edition, 1758–59, that is more important since this has been universally adapted as the basis of Zoological Science.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF MARCH 17, 1936

A regular meeting of the Society was held on March 17, 1936, in the Museum of Natural History. Due to the illness of President Ruckes, Dr. Curran presided, with nineteen members and eight visitors present.

Dr. Curran announced that at the next meeting of the Society on April 7, Dr. William Moore would give an address on "The Red Scale in California" illustrated with slides.

Dr. Klots opened the evening's informal discussion by exhibiting an example of a fake fossil that had been embedded in copalin.

Mr. Rau told of finding ten scale insects new to New York and of three species new to the United States in the Botanical Gardens.

Dr. Spieth described a nymph of the family Oligoneuridæ. It is the first time this family has been reported from North America. The specimen was collected at Decker, Indiana, with a Peterson Dredge. The nymph showed very distinct modifications for living on the sandy bottom of a flowing stream. The reason it has never been taken before probably is due to the fact that most of the collecting is done along the edge of streams and lakes, or else in small bodies of water, and that very little work is done in deeper waters, especially rivers.

Mr. Mutchler in celebration of St. Patrick's Day exhibited a box of green beetles.

LUCY W. CLAUSEN, *Secretary*.

## MEETING OF APRIL 7, 1936

A regular meeting of the Society was held on April 7, 1936, in the Museum of Natural History; Dr. Ruckes in the chair with twenty-five members and twenty-one visitors present.

Dr. Melander reported that Dr. Ruckes would lead the informal discussion at the next meeting.

Mr. Davis told of the death of Dr. Marchand.

Mr. Mutchler exhibited a book written by Harry B. Weiss, "The Pioneer Century of American Entomology."

Mr. Davis spoke of a monograph on the revision of the genus *Ceuthophilus* by Hubbell.

Dr. Ruckes then introduced Dr. Moore, the speaker of the evening, who addressed the members on the "Red Scale in California." In California the red scale and the yellow scale can not be distinguished by structural characters. The yellow scale has a scale covering generally yellow in color and the insects are found on the fruit and leaves. The red scale occurs on the wood and twigs as well as on the leaves and fruit.

In certain districts of California the red scale was found to be more difficult to kill by fumigation with hydrocyanic acid gas than in other districts. These two forms were called resistant and non-resistant red scale.

Further examination of the data showed that the kill of both the resistant and non-resistant red scale is adversely effected by low relative humidities. High temperature favors the kill of the non-resistant red scale whereas low temperature favors the kill of the resistant red scale.

From the history of the red scale at Corona where resistant red scale was first found it appears very unlikely that a tolerance to hydrocyanic acid gas could have been developed as a result of fumigation. It appears, however, that the red scale had considerable difficulty in adapting itself to the climatic conditions of Corona. In making this adaptation some method of conserving water under the drier conditions may have been developed which would not only serve to conserve water but might make it more difficult for the hydrocyanic acid gas to penetrate the insect.

LUCY W. CLAUSEN, *Secretary*.

## MEETING OF APRIL 21, 1936

A regular meeting of the Society was held on April 21, 1936, in the American Museum of Natural History; President Ruckes in the chair with thirty-three members and ten visitors present.

The Program Committee reported that at the next meeting Mr. Davis would address the members on "Reminiscences of the Early Days of the N. Y. Entomological Society."

There being no other reports or miscellaneous business the evening's discussion was opened by Dr. Ruckes who spoke on some interesting facts concerning Heteroptera. Importance was placed on the nature of the head and the contour of the cranium in changing from an hypognathus to a

prognathus type with the consequent underfolding of the mouthparts. The origin of the bending of the beak of the heteroptera comes about through the necessity of getting it out of the way when in the course of evolution the face is pushed dorsally. With specimens to illustrate some western forms of reduviids, coreids and pentatomids some of the various habits and foods of these bugs was mentioned. A series of *Phymata pennsylvanicum* var. *coloradensis* was offered to illustrate a wide range in size and color of a common ambush bug. Particular note was made of the tendency in the Coreidæ for the antennæ and posterior tibiæ to become foliate. Sometimes these expanded segments are so large as to be a quarter to a third of the body area. This is true principally of neotropical forms.

Mr. Davis exhibited a fine series of *Brochymena* representing most of the eastern species and made comments on finding them under varying conditions and on different trees. Attention was called to the resemblance of the bugs to flakes of bark principally from pine. The food habits of these bugs is not completely known and while frequently recorded as feeding on conifers they probably have other food plants as well.

Dr. Melander gave an illustrated talk on the spray resistant San José scale found at the town of Clarkston, Washington. It appears that this scale developed very locally and like the non-resistant type has almost disappeared from that vicinity. Similar records of spray resistant form of the codling moth were also recorded from Washington. Records show that normal sprays, for the scale, had little effect on the Clarkston variety leaving well upwards of 60 per cent. alive when almost total elimination resulted in the common variety. In the case of the codling moth almost 100 per cent. control was effective as a result of early sprays which utilized as little as 1 lb. lead arsenate to 150 gallons of water. In successive seasons, however, stronger and stronger sprays were necessary to procure adequate control.

Mr. Rau showed a number of scale insects and mealy bugs procured from the cultivated plants found in the greenhouses of the Bronx Botanical Gardens.

Mr. Davis called attention to the fact that the tent caterpillars had hatched on Staten Island on April 8 and people were in for a battle with them.

HERBERT RUCKES, *Secretary pro-tem.*



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### INSECT DEVELOPMENT ANALYZED BY EXPERIMENTAL METHODS: A REVIEW

#### PART I. EMBRYONIC STAGES<sup>1</sup>

BY A. GLENN RICHARDS, JR. AND ALBERT MILLER

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<sup>1</sup> This paper was prepared in the biological laboratories of the University of Rochester and of Cornell University.

APR 9 1937

## I. INTRODUCTION

This is the first of two papers having as their joint purpose an analytical review of the available experimental data on all the phases of insect ontogeny. Development from egg to adult is physiologically a continuous process regardless of the form changes involved. Nevertheless we find it convenient to treat the subject under two arbitrary subheads. The present paper is concerned primarily with development within the egg, while the second will deal with development after eclosion from the egg.<sup>2</sup> Recent reviews in English make it unnecessary to cover in detail such general topics as sex determination, determination of types of individuals, action of genes, and chemical changes during development. However, some of the more recent papers are mentioned when they aid in maintaining a proper perspective.

Although experimental insect embryology is still in a very early stage in comparison with experimental vertebrate embryology, it has reached a point where the literature is sufficiently extensive and the results sufficiently definite to make a résumé in English seem desirable. Such a résumé seems especially valuable because our view-point has changed considerably since Morgan (1927) and Schleip (1929) reviewed certain of the outstanding papers.

Most of the important data on the embryonic stages are of recent date. Historically the first experiments were those of Wheeler (1889) and Megušar (1906) on gravitational effect by the inversion of eggs. The first important experiments were those of Hegner on beetle eggs. In 1908 he studied the effects of puncturing the egg and allowing part of the contents to flow out; in 1909 the effects of centrifugal force, and in 1911 the effects of killing regions of the egg with a hot needle. A lapse of about fifteen years followed, during which the little experimental data came from genetical and cytological investigations. Then, with the work of Reith (1925), Seidel (1926) and Pauli (1927), began the series of experiments that will fill the bulk of this paper. To Seidel and his students we owe most of our knowledge of the vital processes occurring in the insect egg.

<sup>2</sup> Berlese's theory which attempts to harmonize the great diversity found in the ontogeny of the various groups of insects will be discussed in Part II.

For our purposes we shall regard '*determination*' as the process of primary chemo-differentiation that 'sets the course' along which a given region of the egg is to develop, *i.e.*, determines its fate. Determination lays the invisible foundation for morphological differentiation. It may, and probably always does, vary in degree, becoming increasingly more strict as development proceeds, and so may also be expressed as 'a limitation of potencies.' *Differentiation* has been aptly defined by Schnetter (1934a) as "visible distinctive configuration." It is the realization, as visible development, of the capacities of a region acquired by earlier or simultaneous chemo-differentiation.

The degree of determination existing in the egg at a given stage of development is reflected in the ability of the egg to readjust itself toward the production of a normal embryo after a defect is imposed upon it. The more fixed the determination, the less the power of regulation. Insect eggs may accordingly be grouped into (1) *indeterminate*, (2) *incompletely determinate* and (3) *determinate* types. An indeterminate type of egg is one in which the parts of the embryo are not predetermined at the time of fertilization, and hence an egg with great regulative powers under experimental conditions. A determinate type of egg is one in which the parts are wholly predetermined before or during fertilization, and hence an egg with little or no regulative power and given to mosaic formation under experimental conditions. An incompletely determinate type of egg is intermediate between these two. A graded series is found from the highly indeterminate eggs in certain of the lower insect orders through incompletely determinate eggs to the completely determinate eggs of the higher Diptera. This indeterminate-determinate series will be discussed in detail later.

Space will not permit a detailed discussion of the morphological course of insect embryogeny. Good accounts are given in recent entomological text-books, *e.g.*, Imms (1934), Weber (1933) and Snodgrass (1935). Such descriptive notes as seem imperative will be given under the forms as discussed.

## II. EXPERIMENTAL MATERIALS AND METHODS

The forms experimented upon include Orthoptera, Odonata, Coleoptera, Diptera and Hymenoptera. Both aquatic and ter-

restrial types have been used; study of the development of the latter is frequently facilitated by immersion in water. Observations on living eggs are possible when they are naturally transparent or translucent and in some cases after removal of the chorion (egg-shell) (*e.g.*, Slifer 1932a, Child & Howland 1933). In experimental studies normal eggs are always used as controls and in some problems 'experimental controls' are also used (*e.g.*, partially *versus* completely constricted eggs). The experimental techniques that have been used may be summarized as follows. [References in italics give methods in detail.]

1. **Cauterization:** (a) Killing a small region or several regions with a hot needle either to produce a minute scar or to eliminate certain areas [Hegner 1911 (Chrysomelid beetles); Reith 1925 (*Musca*, the House Fly), 1931b (*Camponotus*, an ant) and 1935 (*Sitona*, a weevil); Seidel 1926, 1929b (*Platynemisis*, a damsel fly); Strasburger 1934 (*Calliphora*, a blow fly); Howland & Robertson 1934 (*Drosophila*), Oka 1934 (*Gryllus*, a cricket)]. (b) Light cauterization to produce localized contractions of the yolk system [Seidel 1934 (*Platynemisis*)]. (c) Unilateral heating with a microcauterizer to produce minute splits by unequal expansion of the egg materials [Seidel 1928, 1929b (*Platynemisis*)]. (All workers except Hegner used electrically-heated needles, some with micro-manipulator control.)

2. **Irradiation with ultra-violet light** to (a) kill selected nuclei, (b) kill certain areas of the egg, (c) cause temporary changes in the cytoplasm, (d) produce a minute scar, or (e) observe the effect of *in toto* irradiation of oriented eggs [*a-d* Seidel 1929 ff., 1932 (*Platynemisis*); *e* Geigy 1926 ff., 1931b (*Drosophila*)].

3. **Puncturing** the egg with a cold needle, either to allow part of the egg contents to flow out, or to injure, divide or alter the germ band [Hegner 1908 (Chrysomelid beetles); Krause 1934 (*Tachycines*, a camel cricket); Sonnenblick 1934 (*Drosophila*); Howland & Child 1935 (*Drosophila*)].

4. **Producing yolk-fissures** by bending the egg [Seidel 1929a (*Platynemisis*)].

5. **Constricting** the egg (completely or incompletely) at various points with a fine hair [Seidel 1926 ff. (*Platynemisis*);



*Pauli 1927 (Calliphora and Musca)*; Rostand 1927 (*Calliphora*); Reith 1931b (*Camponotus*); *Schnetter 1934b (Apis, the Honey Bee)*; Brauer & Taylor 1934 (Bruchid beetle)].

6. **Centrifuging** the egg in various positions [*Hegner 1909* (Chrysomelid beetles); Clément 1917, 1921 (*Bombyx*, the Silk Moth); *Pauli 1927 (Calliphora and Musca)*; Reith 1932b (*Camponotus*)]. One might also include here the inversion experiments of Wheeler (1889), Megušar (1906) and Hegner (1909).

7. **Modification of environmental factors** [Slifer 1934 (aniso-tonic salt solutions on *Melanoplus*, a grasshopper); Bodine *et al.* (temperature, oxygen tensions, cyanide, etc., on *Melanoplus*), and various workers with temperature, humidity, nutrition, general irradiation with various rays (alpha rays (*Hanson & Heys 1933*), mitogenetic rays (*Wolff & Ras 1934*), x-rays (*Henshaw 1934*, *Smith 1935*)), etc., on various insects].

8. **Genetic analysis** of 'normal' mosaics, intersexes and gynandromorphs in studies on fertilization, cell-lineage, sex determination and to a lesser extent organ formation [*Goldschmidt 1917 ff.* (moths, *Lymantria* and *Bombyx*); *Sturtevant 1929* and *Dobzhansky 1931 (Drosophila)*; *Whiting et al. 1924 ff. (Habrobracon, a wasp)*].

In regard to techniques that have been used upon other invertebrates and upon vertebrates it is of interest to note that (1) separation of early blastomeres is of course impossible due to the superficial cleavage, but this aspect is covered by the above methods nos. 2, 5 and 8; (2) vital staining for marking egg-regions has been tried unsuccessfully by Seidel (he did not remove the chorion) and no. 2*d* above had to be used instead; and (3) tissue culture methods, parabiotic twinning and operative technique in the sense of transplantations have not been successfully accomplished with insect eggs. The tough chorion together with the turgidity and fluidity of the egg contents hinder manipulation.

### III. ORIGIN OF POLARITY AND SYMMETRY

Insect eggs vary greatly in form but may be broadly classified as either radially or bilaterally symmetrical. In either case the eggs may be laid in definite or random positions depending on the species. In bilaterally symmetrical eggs the axes of the presumptive embryo may be externally evident.

1. **Hallez's Law of Orientation:** This 'law' is based on the observation that the mature egg within the ovary lies in such a position that all three axes of the presumptive embryo are oriented coincidently with those of the mother. From this it follows that the embryonic axes are determined in the egg before laying. Although this is certainly a general rule it is not yet proven to be universal. In the radially symmetrical egg of the bug *Pyrrhocoris* Seidel (1924) reports that the longitudinal embryonic axis may vary from being coincident with the longitudinal axis of the egg to being transverse to it. Also there are certain insects (e.g., *Melanoplus*, Slifer 1932a) in which it is reported that the embryo begins to develop in the reverse position with the head towards the micropylar opening at the posterior end of the egg but that the 'normal' position is attained by a later reversal of the embryo during blastokinesis.

Seidel (1929a) reports that frontal doubling, induced by the production of splits in the egg at the beginning of cleavage and resulting in the formation of mirror-image symmetrical twins within the egg, indicates the determination of a dorso-ventral axis (as well as other axes) at this early stage in the development of *Platynemis*. Mirror images result from the inversion of one of the three axes in the formation of one partner; this presupposes the existence of polarity at least in the inverting plane. Frontal and lateral doubling have also been induced by splits in the germ band of *Tachycines* (Krause 1934).

2. **The position of the micropyle** is determined by the formation of the egg-shell during growth of the oöcyte. It is usually situated at the center of the anterior end of the egg but may be on one side (Weber, 1933, p. 488) or even at the posterior end (Slifer 1932a). If the point of entrance or course of the sperm is concerned in the determination of the embryonic axes then these in turn are more or less fixed by the position of the micropyle and hence influenced by ovarian factors.

3. **Visible bilaterality** is frequently evident in the external structure and form of the mature egg. A corresponding visible internal bilaterality is sometimes shown by the constant position of the "richtungsplasma" (place where the maturation divisions occur) on the dorsal or ventral mid-line of the egg (Schnetter

1934a, Strasburger 1934). Hirschler (1933) has demonstrated by intra-vitam staining that the original radial symmetry of the egg becomes obviously bilateral during deposition of the yolk in the beetle *Cicindela* but he did not study the relation of this symmetry to that of the future germ band; the two may be coincident.

4. **Germ-Tract Determinant** (germ-plasm, germ-line, pole-cells, pole-disc, Polscheibe, Keimbahn): There is frequently an area of distinct appearance at the posterior end of the unfertilized egg. The cleavage nuclei which enter this region are destined to give rise to the definitive germ cells of the embryo. This area frequently contains numerous granules that stain conspicuously. Huettner (1923) shows that they are neither small yolk granules nor mitochondria; presumably they are merely byproducts of the 'germ-plasm.' In any event the area is most probably determined by extra-oval factors and does not act in the determination of the embryonic axes.

5. **Gravity and centrifugal force:** Wheeler (1889) and Hegner (1909) report that the position of the eggs of the Cockroach and Chrysomelid beetles has no effect on development. The single reported exception is the beetle *Hydrophilus* in which Megušar (1906) reports that if the aquatic egg-capsules are inverted development is retarded and the few larvæ which hatch are deformed and soon die (the embryos, however, were in their normal position within the eggs). His results, based on only two capsules of eggs, are inconclusive since he did not consider the modification produced in factors other than gravity, for instance the inversion of air-water relations.

Hegner (1909), Pauli (1927) and Reith (1932b) report that the orientation of embryos produced by centrifuged eggs is unaffected although the visible materials are redistributed and stratified. Centrifugal force has much less effect on eggs within the ovaries (Hegner 1909, Clément 1917, 1921), either due to less effect on growing or mature oöcytes or to a restitution within the oöcyte.

From the above fragmentary notes it is evident that the fundamental processes underlying the determination of polarity and symmetry are still a matter of conjecture. In bilaterally sym-

metrical eggs, at least, both polarity and symmetry must be determined during growth of the oöcyte. The development of polyembryonic eggs (certain parasitic Hymenoptera) might throw some light on this question but the available data can not be analyzed from this view-point. Cappe de Baillon's (1925b) data clearly suggest to us that this early determination of the fundamental axes begins at or near the anterior end and progresses posteriorly (see Section VI).

#### IV. FERTILIZATION

1. **Activity of the spermatazoa:** Activated sperm have an undulatory movement but it is not known whether this movement functions during penetration of the insect egg or only furnishes motile power to pass through the micropyle. The tail, in all reports we have noted for insects, is carried into the egg. How the sperm move through the interior of the egg after entrance is unknown, but it is of interest to note that Huettner (1927) observes their distribution throughout the egg in abnormally highly polyspermatic eggs of *Drosophila*. Also little is known concerning the reactions of the sperm themselves, but Howland (1932) reports that in *Drosophila* the sperm are highly sensitive to the constitution of the surrounding medium and easily killed.

2. **Monospermy and polyspermy:** In some insects only a single sperm can be found within a fertilized egg (Johannsen 1929) but in most insects several or many sperm enter. Huettner (1924, 1927) reports that supernumerary sperm in *Drosophila* eggs degenerate, only rarely forming mitotic figures. If, however, the degree of polyspermy is too great it may lead to disturbances which prevent further development. These disturbances are usually due to disorganization of the maturation divisions by sperm which enter this region of the egg. Such sperm may form uni-, bi- or multipolar spindles, or even enter normal spindles to form multipolar figures. This condition may or may not become adjusted. In binucleate moth eggs Doncaster (1914) and Goldschmidt & Katsuki (1928) report that each nucleus fuses with a sperm. Genetic evidence shows that the same is true for some binucleate eggs of the wasp *Habrobracon* (Whiting 1934). In no case is there any evidence of a sperm



functioning except after uniting with an egg nucleus, but Huettner (1927) postulates that such is possible and shows that it might conceivably be followed by normal development.

**3. Selective fertilization:** In the true sense this is unknown in insects although it may be simulated in some instances by a partial or complete mortality of one of the expected types. This is presumably the case in sex determination in the Hymenoptera where according to Whiting's theory (1933) biparental progenies should be composed of diploid males and females in equal number. He shows by genetic tests with sex-linked genes and by an inverse correlation of biparental males with total progeny and with egg-hatchability, that the fusion of like gametes is usually lethal—fusion of unlike gametes giving females (normal males are haploid and result from parthenogenesis). A presumed case of selective fertilization in *Drosophila* has been shown due to the necessity of the dominant allelomorph at some time during development even though it be expelled into a polar body (Morgan 1927, p. 58).

**4. Activation of the egg by the sperm:** Ripe insect eggs are usually found to be in the metaphase of the first maturation division and to depend on the entrance of the sperm or the induction of parthenogenesis to continue further (Huettner 1924, Johannsen 1929, and others). In normally parthenogenetic species there is no such cessation at this point, and even in the grasshopper *Melanoplus* which is normally fertilized at this stage King & Slifer (1934) report that there is no visible delay in unfertilized eggs and that the maturation divisions proceed to completion at very nearly the same rate as in fertilized eggs. Accordingly the sperm does not necessarily have an activating function even in eggs which ordinarily undergo fertilization.

**5. Relation of fertilization to cleavage and later development:** It was pointed out above that since the point of entrance and path of the sperm are probably constant in any one species due to the position of the micropyle, it is uncertain whether they bear any relation to the origin of the orientation of the embryo. The only cases in which any part of fertilization is thought to have a bearing on development, other than initiating completion of the maturation divisions, is in incompletely determinate eggs. In this type of egg Reith (1931b, 1935) reports that induction of

the visible zonation of the cortical layer of the ant egg and a similar but not visible determination in the beetle egg start immediately after the beginning of cleavage. How this activation of the activation center is brought about and whether it is caused by the entrance of the sperm, the fusion of the pronuclei or some other factor are unknown.

6. **Fertilization membranes** are seldom mentioned for insects. In the Silk Worm Bataillon & Su (1931a, 1933) report that a strong fertilization membrane is detached from the egg following induced parthenogenesis and in the first brood of two-brooded stocks but not in the second brood or in single-brooded stocks. The significance of this variation is not known.

7. **Centrioles** are present in the eggs of some species, absent from others. Huettner (1933) shows that they are absent from the maturation figures of the egg of *Drosophila* but that they appear at the first cleavage (from the sperm?) and thereafter have a continuous history throughout development. Nachtsheim (1913) believes that in the Honey Bee they are derived from the egg since supernumerary sperm form anastral spindles whereas cleavage cells have conspicuous centrioles. Bataillon & Su (1931b, 1933) report that in the Silk Worm egg they do not appear except from the sperm, and that they are never found in parthenogenetic eggs. Their absence from these parthenogenetic eggs is frequently accompanied by highly abnormal mitotic figures.

8. **Binucleate eggs**: These may and presumably do arise from two different causes: (1) the functioning of two maturation nuclei of a single egg, and (2) the fusion of two eggs. Strangely enough the fusion of two eggs does not result in a giant egg which in turn produces a giant individual. Morgan (1927, p. 466) suggests that two oöcytes may fuse early in growth, and then having only the nourishment of a single egg not grow beyond normal size.

On purely genetic evidence Whiting (1924, 1934) postulates the functioning of two maturation nuclei of the egg (pronuclei) to account for haploid mosaic males in the wasp *Habrobracon*. On similar data he shows that in the case of fertilized eggs either one or both of such nuclei may fuse with a sperm. Detailed

analysis of his data leads us to accept his postulate that the two nuclei are derived from the maturation nuclei of a single egg rather than from fusion of two oöcytes. Goldschmidt & Katsuki (1928) report both the cytology and genetics of a similar case in the Silk Worm Moth. Here it is produced by a recessive gene tending to form binucleate eggs, and the genetic evidence proves conclusively that two functional nuclei come from the egg in all cases. Doncaster (1914) had already found binucleate moth eggs cytologically, each nucleus accompanied by three polar bodies and being fertilized by a separate sperm nucleus. This is conclusive proof that in this case we are dealing with an egg containing two diploid nuclei, not with an egg in which two reduced (maturation) nuclei are functioning. Also Morgan and his coworkers (1914, 1919, 1923) show genetically that binucleate eggs are the most probable explanation of certain exceptional specimens of *Drosophila*.

In addition to the above cases there are the following definitely referred by the authors to the fusion of two oöcytes. In the wasp *Copidosoma* Hegner (1914b) claims that two oöcytes regularly fuse, one furnishing the nucleus of the mature egg, the other furnishing the germ-tract determinant. Patterson (1917, 1921, 1927) in dealing with closely related species does not mention this claim nor cite this paper of Hegner's. In agreement with earlier authors he describes the mature egg as arising from a single oöcyte, the germ-tract determinant originating from the nucleolus. Cappe de Baillon (1925, 1927) is the strong proponent of oöcyte fusion to give bi- and tri-nucleate eggs. According to him the determination process in the cortical layer of the egg of the phasmid *Carausius morosus* begins during growth of the oöcyte. If the fusion occurs sufficiently early or if the fusion planes happen to coincide a normal embryo will result, but if the fusion planes do not coincide an egg with two separately determined plasma regions will result. He finds all stages from normal embryos to two separate embryos within one egg. To corroborate this hypothesis he, as well as Zakolska (1917) and Tur (1920), has found various stages in the fusion of growing oöcytes within the ovary. Von Lengerken (1928) accepts Cappe de Baillon's hypothesis and describes several presumably additional

cases from the beetles *Carabus* and *Lucanus*. In these non-parthenogenic forms oöcyte fusion may result in the production of gynandromorphs.

Whether or not the origin is the same in all cases there can be no doubt that binucleate eggs occur in such widely separated groups as phasmids, moths, beetles, wasps and flies. In all the above cases the egg is reported as responsible, supernumerary sperm never functioning except when they unite with an egg nucleus. [Huettner (1927) shows that in *Drosophila* supernumerary sperm might conceivably function without fusion but his point is yet unproven.]

9. **Trinucleate eggs:** As with binucleate eggs there are at least two possible methods of origin of trinucleate eggs. Cappe de Baillon (1927) figures trinucleate eggs of *Carausius*, his figures indicating that they have arisen by the fusion of three separate oöcytes. Whiting (1934) postulates trinucleate eggs in *Habrobracon* because mosaic males bred from virgin females sometimes show three or even four possible combinations of maternal characters. He also reports one gynandromorph thought to have arisen from a trinucleate egg one nucleus of which became fertilized.

10. **Parthenogenesis:** There are some insects in which all individuals develop parthenogenetically from non-reduced eggs (giving only females); such parthenogenesis may be either constant or cyclic but is always obligatory. In Hymenoptera and certain other forms reduced but unfertilized eggs normally produce males. In other insects parthenogenetic development of reduced eggs occurs occasionally or can be induced. A detailed treatment is given by Weber (1933, p. 514) so only a representative set of cases is cited here.

Goldschmidt (1917) gives a detailed analysis of a case of facultative parthenogenesis in the Gypsy Moth. Clément (1917, 1921) reports that it is sometimes induced by centrifuging Silk Worm eggs. Bataillon & Su (1931a) report that it can be induced by chloroform or weak acids in Silk Worm eggs and that it frequently results in an activation superior to that of fertilization. Harrison (1933) and others have reported that it is sometimes induced by attempted hybridization. A peculiar case is reported



by Shull (1930a) for aphids. Here the mode of reproduction of an individual is determined before birth by external factors (light & temperature). It is the determination of the mode of reproduction of an individual by the action of factors upon its mother rather than upon the generation affected.

Slifer & King (1932) and King & Slifer (1934) report that in unfertilized eggs of the grasshopper *Melanoplus* the maturation divisions are completed at nearly the same rate as in fertilized eggs. The embryos developing from these eggs frequently contain both haploid and diploid cells. This, as well as genetic evidence from parthenogenesis in the grouse locusts (King & Slifer 1933), indicates that the maturation divisions are normal and that there is no fusion of a polar body nucleus with the true egg nucleus but that during cleavage there is a doubling of chromosomes without separation into two nuclei. The animals reared to maturity were all females. This, coupled with the fact that from thousands of unfertilized eggs several hundreds hatched but only about twenty lived to maturity, seemingly indicates that only those individuals which successfully attain a diploid condition live to maturity. Since the second generation gave results similar to the first the high mortality must be ascribed to the haploid condition itself, not to uncovered lethal genes.

## V. CLEAVAGE AND BLASTODERM FORMATION

The insect egg is made up of a central yolk mass enmeshed in a slight cytoplasmic reticulum and surrounded by a relatively thin layer of dense cytoplasm—the cortical layer or periplasm. At the time of union of the sperm and egg nucleus the latter lies somewhere within the yolk region of the egg (its position probably being constant in any particular species). Due to this position and the centrolecithal yolk distribution, cleavage is of the superficial type in all the species treated in this review, *i.e.*, cleavage consists of nuclear divisions accompanied by division of only the small cytoplasmic area immediately around the nucleus (the so-called 'protoplasmic island'), true cell formation not occurring until the cleavage nuclei penetrate the cortical layer where they give rise to the multicellular blastoderm. [This type of cleavage is peculiar to the arthropods but is not universal among the insects.]

No development occurs if the early cleavage nuclei are killed by cauterization (Reith 1925, 1931b, Pauli 1927)—the formation of an enucleate 'blastoderm' in unfertilized eggs of *Phragmatobia* hybrids is an apparent exception (Seiler 1924, see Section V-B). Nuclei must enter the region of the activation center (*q. v.*) before differentiation of the germ band can occur in *Platycnemis* (Seidel 1932), but in *Camponotus* this center functions before it becomes nucleated (Reith 1932b). The cleavage divisions are not inseparably bound up with the early developmental processes since they continue for some time after elimination of the activation center (Seidel 1929b, Reith 1931b) or after blocking of all development by x-irradiation (Henshaw 1934).

#### A. Specialization of Nuclei

The cleavage nuclei are usually but not always indeterminate or totipotent at least until blastoderm formation (Sturtevant 1929, Seidel 1932). In *Platycnemis* Seidel (1932) reports that neither abnormal or delayed nuclear distribution nor elimination of one of the first two nuclei prevents formation of a normal embryo, nor does a decreased number of nuclei necessarily delay the onset of determination and differentiation. Equipotentiality of the nuclei is also indicated in the experimental results of Hegner (1908), Reith (1925) and Pauli (1927).

At first the cleavage divisions occur synchronously,<sup>3</sup> but sooner or later this synchrony ceases and heterochronous divisions begin, usually during blastoderm formation. Heterochronism may be regarded as the first indication of nuclear differentiation, but in some cases it is preceded by vitellogophs being left behind in the yolk.<sup>4</sup> In *Platycnemis* the nuclei reach the surface between the fifth and sixth divisions but heterochronism does not set in until the tenth division. Seidel (1929b) reports that there is some indication that cleavage ceases after the last synchronous division when the activation center (*q. v.*) is eliminated. In *Ephestia*

<sup>3</sup> Synchrony of cleavage divisions has been reported in Apterygota, Orthoptera, Dermaptera, Aphidæ, Odonata, Coleoptera, Lepidoptera, Hymenoptera and Diptera (see Schnetter, 1934a, table 12). If the onset of a different division rhythm for the germ-tract nuclei be counted the number of synchronous divisions varies from three in *Miastor* to ten in *Apis*.

<sup>4</sup> Ordinarily the vitellogophs arise from nuclei that migrate back into the yolk from the blastoderm. For a tabular summary of the data on vitellogoph origin see Schl, 1931, p. 570.

and *Apis* heterochronism begins with the tenth and eleventh divisions respectively, when the nuclei enter the cortical cytoplasm. Schnetter (1934a) describes the heterochronous division in *Apis* as proceeding in 'waves,' the mitoses occurring first in a definite region of the egg (see Section VII-B) and spreading successively to neighboring nuclei. In the Diptera those cleavage nuclei which happen to enter the germ-tract determinant region at the posterior pole of the egg cease dividing synchronously with the other nuclei as soon as they become segregated as 'pole cells,' although synchrony continues independently within each set of nuclei at a different rate from that in the other set. In the fly *Sciara* DuBois (1932) reports the elimination of whole chromosomes from all nuclei at the fifth division and prior to the segregation of the germ-tract nuclei, and further elimination during the seventh to ninth divisions from the remaining (somatic) nuclei after germ-cell segregation. In *Miastor* Huettner (1934) reports the elimination of three-fourths of the total number of chromosomes from the somatic nuclei during the third and fourth cleavage divisions and after the segregation of the germ cells (reduction from octoploid to diploid condition). In neither case is the division synchrony affected by this elimination. In *Camponotus* Reith (1931b) reports that after early destruction of the activation center, the usual zonation of the cortical layer does not occur and no true blastoderm is formed, yet the cleavage nuclei differentiate into visibly distinct types (embryonic and extra-embryonic). At present these various types of nuclear differentiation cannot be attributed to a common factor. Cytoplasmic influence seems operative in germ-cell differentiation in the Diptera and possibly in the described behavior in *Camponotus*; the developmental centers (Section VII) through their effect on cytoplasm, other oöplasmic constituents or nuclear migration, may influence division heterochronism in *Platynemís* and *Apis*; whereas intrinsic factors in the nuclei themselves may be more directly responsible for chromosome elimination in the lower Diptera and for vitellophag formation.

### B. Migration of Nuclei

In *Platynemís* Seidel (1932) reports that the first four cleavage nuclei are oriented at intervals along the longitudinal axis (Fig.

1a). He says this is due to a strong repulsion tendency of the mitotic figures against one another and against the surface of the egg, the tendency becoming reduced as the nuclei and protoplasmic islands become smaller. He observed occasional cases of atypical distribution which he thinks due to an absence or failure of this tendency, but one would expect visible abnormalities in mitoses if such were true. Seidel also reports that the activation center (Fig. 1 a-b) is not concerned in nuclear migration since the distribution of the nuclei occurs almost or quite normally when this center is completely constricted off from the rest of the egg.

In the butterfly *Pieris* Eastham (1927) shows that the cytoplasm of the protoplasmic islands extends into the cytoplasmic reticulum of the yolk in the form of long tapering strands distributed around the nucleus. Via these strands the cytoplasm of the protoplasmic islands is continuous with that of other islands and of the cortical layer. Therefore the egg is a true syncytium with each nucleus lying in the center of a small cytoplasmic area. As cleavage begins the mitotic figures are oriented at random and result in a cluster of nuclei. The first indication of their migration is the formation of a small hollow sphere of nuclei. In this sphere subsequent nuclear divisions occur parallel to the surface with the result that the spherical arrangement is maintained. Concerning the migration itself Eastham believes the nuclei are moved passively through the yolk by centrifugal streaming because, (1) flecks of cytoplasm are frequently seen elongated in the direction of nuclear movement; (2) the comet-like tails of the protoplasmic islands stretching out behind the migrating nuclei are also present during mitosis when the nucleus is not thought of as active; (3) as the nuclei approach the cortical layer the intervening area becomes visibly richer in cytoplasm, and (4) conversely the area within the nuclear sphere becomes poorer in cytoplasm. In addition he notes that the nuclei are first nearer the cortical layer in the lateral and anterior regions but that then the posterior nuclei move more rapidly thereby changing the shape of the nuclear sphere (first reach surface antero-ventrally). During this time each nucleus moves to the peripheral end of its protoplasmic island, and, as it enters the cortical layer, becomes



elliptical with its longitudinal axis parallel to the egg surface (evidence of pressure between nucleus and cortical layer). The comet-like tails are then drawn in and spread out to fuse with one another enclosing a thin layer of yolk peripheral to their points of fusion. This visibly distinct cytoplasmic layer is called the 'inner cortical layer.' Sehl (1931) reports fundamentally the same for the moth *Ephestia*.

In the Honey Bee Schnetter (1934a) divides the kinematic appearances into three phases: (1) first four divisions near the anterior pole with successive spindles at right angles to one another (Sach's Law) and giving first a quadrant then a hollow sphere of sixteen nuclei; (2) fifth to seventh divisions in a longitudinal direction, tangential to the surface of the elongating sphere, the center becoming almost devoid of cytoplasm, the periphery rich; and (3) migration to the cortical layer during the seventh to tenth divisions, the movement being most rapid in the widest region of the egg and toward the ventral side. The first vitellophags arise by radial division of one or two nuclei during the seventh division, and are described as moving inward against the general outward movement. He refuses to commit himself as to how the nuclei move but it certainly is not merely a repulsion tendency of the mitotic figures.

In the ant *Camponotus* and the beetle *Sitona* Reith (1931b, 1935) reports that early elimination of the activation center does not affect nuclear movements despite the fact that this center normally functions during cleavage.

In *Calliphora* Strasburger (1934) reports that an oval sphere of nuclei is formed at the sixteen-nuclei stage. During metaphase each mitotic figure lies tangential to the surface of this sphere, but during telophase, when no spindle fibers are apparent, the daughter nuclei move in a radial direction in such manner that the mitotic axis bends and the nuclei lie at an acute angle to each other until completely separated. In this connection it is seen that the position of the nuclei at the peripheral end of the protoplasmic islands is correlated with mitosis—the spindle is at the center during metaphase, at the peripheral margin during telophase. The nuclei enter the cortical layer synchronously, but this synchrony of movement is not especially important since

disturbances in it merely result in part of the embryo anlage developing sooner than the rest, a normal embryo being eventually formed. Strasburger suggests that the protoplasmic streaming is due to active movement of the protoplasmic island or its parts since in lightly cauterized eggs no such streaming is visible in non-nucleated but "uninjured" parts of the egg. However formation of the inner cortical layer is clearly a plasma streaming without nuclear influence for when the nuclei are delayed the cortical layer thickens prior to their entrance (greater ventrally than dorsally). In *Drosophila* Huettner (1935) says that there are three types of movements: (1) first eight divisions resulting in the even distribution of 256 nuclei throughout the egg; (2) movement into the cortical layer; and (3) movement of the posterior nuclei in the formation of the germ cells. He thinks that the first type of movement is "partially conditioned by the mitotic spindle," though other factors must be involved since the nuclei continue to move slightly when spindles are not present [viscosity changes concurrent with mitosis might be a factor here]. He offers no explanation of the second type, but refutes the possibility of protoplasmic streaming because of vitellophages being left behind. He thinks the third type probably due to a combination of spindle action and protoplasmic flow.

*Analysis of the motivating factor or factors* in these nuclear movements is difficult because of the inability to separate cause from effect in observational data. There is certainly no amoeboid movement exhibited by either nucleus or protoplasmic island. The movement is not impeded by repeated mitoses during migration, in fact, Huettner (1935) says movement may in certain cases be accelerated during mitosis in *Drosophila*. The movement of the centrioles during mitosis shows that they cannot be the causative factors even though they constantly lie towards the egg-periphery in undividing nuclei (Huettner 1933, Strasburger 1934). The repulsion tendency cannot possibly function to cause centrifugal movement of the nuclear sphere.

There remain three possibilities: (1) active nuclear movement which pushes the cytoplasm in front of it and draws that behind; (2) plasma streaming which carries the nuclei along passively, and (3) some unknown attractive influence from the surface

region. The only observation that can be considered in favor of the first hypothesis is Strasburger's report that plasma streaming does not occur in non-nucleated but seemingly uninjured parts of the egg of *Calliphora*. But this is by no means conclusive evidence even for this species since he does not consider such questions as the possible failure of local activation, altered viscosity or other possible invisible physico-chemical changes in these cauterized eggs. He attempts to circumvent the difficulty of ascribing active nuclear movements to the nucleus by suggesting that the movement is due to the protoplasmic island in whole or part, but this is unsupported and also conflicts with his own data on the formation of the inner cortical layer and with Seiler's data to be discussed below. Another possibility that has not been suggested by any previous author is that the qualitative differences between the various nuclei, as expressed by the non-migration of vitellophags, might conceivably result in surface-tension phenomena around each nucleus. Such differences, arising from differences in the nuclei themselves, might possibly inaugurate the general plasma streaming and also cause the differences between the movements of various nuclear-types, perhaps largely by causing the vitellophags not to participate in the general outward movement or actually to move against it. In favor of the second hypothesis, plasma streaming, there are two positive observations. (1) Strasburger's report that when some of the nuclei anterior to the point of cauterization are delayed from entering the cortical layer in eggs of *Calliphora* the inner cortical layer is formed in those regions before the nuclei reach it. (2) Seiler's report (1924) that the eggs of *Phragmatobia* (moth) hybrids occasionally undergo 'cleavage' of the cortical layer to form a pseudo-blastoderm even though no cleavage nuclei are present in the egg. His illustrations show clearly that those areas which undergo this 'cleavage' process have a considerably thickened cortical layer. Both of these cases certainly represent a plasma streaming without nuclei, from which it is reasonable to assume that the plasma streaming is the primary factor in these movements. But plasma streaming alone leaves unexplained those cases where vitellophags are left behind in the yolk (unless the plasma streaming is local and caused by

the nuclei—its general appearance being due to a summation of local effects around each nucleus. (See above). The third hypothesis is indefinite. It is included here partly as a possible answer to the occasional non-migration of vitellophags, partly as a possible source of origin of the plasma streaming (see below).

The factor or factors causing the centrifugal migration of the nuclei must be the same that bring an end to the random orientation of the mitotic figures and arrange the nuclei in the form of a hollow sphere. It would seem that only a centrifugal plasma streaming could accomplish this. But from what could such a plasma streaming originate? Certainly not directly from randomly oriented nuclei. Perhaps it is unwise to attempt delimitation to any single factor or part, but it seems possible that the stimulus might arise from the distant influence of the cortical layer. The original shape, later movements and change of shape of the nuclear sphere are not too well correlated with the original thicknesses of the various regions of the cortical layer so it can scarcely be a truly quantitative relationship. Nevertheless Schnetter (1934a, p. 161) points out that there are certain quantitative correlations in the Honey Bee egg. He describes the outward movement of the nuclei as occurring in waves passing anteriorly and posteriorly from the region of the differentiation center (*q. v.*), the nuclei first reaching the surface anteriorly and ventrally near the locus of polar-body formation, and suggests that a motivating impulse is transmitted from the differentiation center following the release of the qualitatively distinct "Richtungsplasma" into the periplasm. There are, then, two possible origins of this centrifugal movement, both hypothetical: (1) a more or less general effect from the cortical layer, or (2) qualitative differences not necessarily included in the developmental centers although sometimes correlated with the differentiation center. Either is substantiated but not proven by Strasburger's observation that light cauterization of the egg of *Calliphora* frequently results in a displacement anteriorly of the nuclear sphere. If either of these suggestions is true, then the origin of the plasma streaming is one of the first indications of the activation of the *general* dynamic egg system<sup>5</sup> (see Section

<sup>5</sup> In a sense vitellophags left behind in the yolk form an exception here as was noted in the last paragraph. But, just as they are sometimes visibly



VII-C). Whether such influence acts by changing concentration gradients or by some other means is totally unknown. In this connection we might add that Hegner (1909) has shown that the contents of Chrysomelid beetle eggs are more easily stratified by centrifugal force during late cleavage than at any time before or after. Presumably the egg contents are less viscous at this time. Also Pauli (1927) notes that after reorganization of the disarranged egg contents the nuclei come to lie near the boundary between zones or distribute themselves evenly over the surface of the egg.

It should also be noted that in the indeterminate-type eggs of *Platynemís* and *Tachycines* further migration occurs after the nuclei are uniformly distributed over the surface. The cells assemble in two groups (ventral in *Platynemís*, dorsal in *Tachycines*) which finally come together on the ventral side of the egg to form the embryonic rudiment (Seidel 1929b, Krause 1934). This peripheral migration, at least in *Platynemís*, is caused by a contraction wave in the yolk system (see Section VII-B), and hence is passive. In more determinate types of eggs (*e.g.* moth, bee, etc.) the embryonic rudiment arises by differential thickening of the blastoderm, not by cellular migration.

### C. Stimulation to Blastoderm-Cell Formation

Seidel (1932) reports that if the activation center (*q.v.*) is eliminated in *Platynemís* by constricting the egg, there is a delayed formation blastoderm of extra-embryonic type anterior to the constriction. Reith (1931b) reports a somewhat similar state of affairs in *Camponotus*, where if the activation center is eliminated immediately after fertilization the nuclei reach the

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distinct, so too there must be some intrinsic difference between vitellophag and blastoderm nuclei. Since plasma streaming is a proven fact and in at least some cases has a definite relation to blastoderm formation (see Section V-C), we prefer for the present to consider nuclear movement as passive and these vitellophag cases as exceptions to the *general effect* of plasma streaming rather than as absolute refutation of any causal significance of the streaming. Another possibility is that the intrinsic nuclear differences result in local surface tension phenomena at the surface of the various nuclei and so influence the plasma streaming in their own immediate vicinity or the movement of the particular nuclei in this streaming.

surface of the egg but are incapable of blastoderm formation, nevertheless they undergo differentiation into embryonic and extra-embryonic types.

Eastman (1927) reports that in *Pieris* the nuclei enter the cortical layer perpendicularly and move outward through the cortical layer to protrude beyond. It is difficult to say whether this protrusion is due to continued outward movement of the nuclei or to withdrawal of the cytoplasm between them. At this time the cytoplasm of the cortical layer can still be distinguished from that of the protoplasmic islands, and it is from the outer part of the cortical layer that the cell walls begin to develop. By this time the 'tails' of the protoplasmic islands have been drawn in and fused with those of neighboring nuclei to form the inner cortical layer. The cell walls now grow inwards between the nuclei; the basal membrane is then formed through the center of the inner cortical layer dividing it into two thin layers. The walls begin to develop anteriorly where the nuclei first enter the cortical layer, and are completed ventrally before dorsally.

Seiler (1924) reports a case in the eggs of *Phragmatobia* (moth) hybrids that has remained unique among insects. These eggs were presumably unfertilized since no sperm could be found and the egg nucleus, which remained lying at the point where the two nuclei usually fuse, soon disappeared and left only the protoplasmic island to mark its former position. Such eggs frequently ("hundreds") underwent partial or complete division of the cortical layer into blastoderm cells of fairly normal appearance but without nuclei. He found all stages from early division to a complete 'blastula,' and his photos leave no question of the authenticity of his observations. It is of particular interest that the division was not uniform throughout the egg but was quite 'spotty.' The parts of the cortical layer that divided became thickened (as in normal eggs) in contrast to unthickened in undivided parts and in eggs that did not develop. There is, then, a definite correlation in this case between the thickening of the cortical layer and its division into 'cells.'

Schnetter (1934a) reports that the Honey Bee is very similar to *Pieris*, differing principally in that the basal membrane is formed before the formation of the inner cortical layer. It soon

disappears, the inner cortical layer is incorporated into the blastoderm, and then the basal membrane is re-formed.

Experimentally Strasburger (1934) shows that there is a definite time relation between the entrance of the nuclei into the cortical layer and the formation of cell boundaries in *Calliphora*. Normally both occur synchronously throughout the egg, but when the nuclei enter the cortical layer first at the anterior end (either abnormal distribution or experimental hindrance) the cell boundaries also form there first. [This time relation is also seen in cases where the nuclei do not enter the cortical layer synchronously, *e.g.* first reach surface ventrally in *Ephesia* (Sehl 1931), antero-ventrally in *Pieris* (Eastham 1927), etc. In these cases the cell walls form first in those parts where the nuclei first reach the surface.]

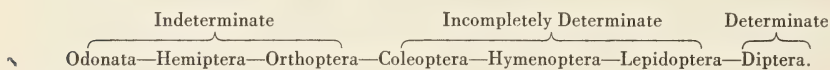
From the above data four points are noteworthy: (1) Seidel's and Reith's observations that delay in (*Platycnemis*) or failure of (*Camponotus*) cell-wall formation occurs after elimination of the activation center; (2) Eastham's observation of the formation of cell boundaries from the cytoplasm of the *original* cortical layer; (3) Seiler's observation of 'cell' formation without nuclei but with a thickening of the cortical layer; and (4) Strasburger's demonstration of the formation of cell walls at a definite time after entrance of the nuclei into the cortical layer. The first suggests that cell formation is aided or determined by the activation center; the second might be interpreted as suggesting that there is a predetermination of the cortical layer to form cells; the third must be interpreted as either a partial activation causing both localized streaming and cell formation or as a partial activation causing streaming which in turn causes cell formation; and the fourth suggests that cell formation is wholly a function of the nuclei. The natural assumption is that all these factors are involved but that they have different potencies in different insects.

## VI. THE INDETERMINATE-DETERMINATE SERIES

By differences in the time of appearance of the visible morphological characteristics of development, especially the germ

cells, Seidel (1924) showed that it is possible to establish a series ranging from indeterminate through incompletely determinate to determinate types. In indeterminate eggs the visible separation of regions of different prospective significance occurs after blastoderm formation, and organ segregation follows after differentiation of the germ layers and segmentation. In determinate eggs this visible differentiation occurs before or during blastoderm formation.

Following this lead experiments were devised by Seidel and his students to determine if this series is also illustrative of the potencies of the egg parts as determined by the regulative power or conversely the degree of predetermination of the egg parts. These studies have shown that Seidel's series is fundamentally accurate both for visible differentiation and for the degree of predetermination of the various egg parts. From both viewpoints it is a matter of time (time or stage of visible differentiation and time of determination), indeterminate eggs becoming more and more determinate as development proceeds, determinate eggs being fully determined by the time of fertilization. Schnetter gives the following revised scheme:



Whether or not Schnetter is justified in listing the above sequence seems open to question. In the first place no experimental data are available for either the Hemiptera or the Lepidoptera, and these two orders are placed in the series wholly on a basis of the time of visible differentiation of the various parts. A more serious criticism lies in the implication of homogeneity within single orders. Experimentally only a single species of Odonata has been studied, two Orthoptera, two higher Hymenoptera, three Coleoptera and three higher Diptera. As will be pointed out below there is good reason to expect considerable variation within the order Hymenoptera, polyembryonic forms seeming to be highly 'indeterminate.' Perhaps similar variation will be found within other orders.

**Indeterminate eggs** have a certain amount of determination at the time of fertilization. Bilaterally symmetrical ones have



the polarity and dorsal and ventral sides irrevocably determined. In the absence of experimental data it is not possible to evaluate the variation in position of the embryo of the radially symmetrical egg of the bug *Pyrrhochoris* (see Section III); though the embryonic axis varies through  $90^\circ$ , it is not possible to say whether its position is determined before, during or after fertilization. Except for the fundamental axes indeterminate eggs possess great regulative powers as shown by dwarf embryos and duplications. Experimentally produced twins and duplicated parts show that there is in the early blastoderm a specific disposition of materials for the formation of the germ band but that when these materials are separated each part tends to form a whole structure rather than only an isolated part. This power becomes more limited as development proceeds, but studies on regeneration show that the power of regulation is not entirely lost until the adult stage (see Part II).

In *Platytenemis* Seidel (1928, 1929a) reports that shortening the longitudinal axis by constricting the egg results in dwarf but otherwise normal embryos. Duplications which result from splits induced by cautery also show that the prospective potency of the egg parts is greater than the prospective significance at the time the various anlagen are set apart; each duplicated part is larger than one-half the size of the same organ in a normal embryo, so that the sum of the two duplicated parts is greater than the size of a single normal organ. This power of duplication is possessed by all organs, external and internal. It never occurs in the longitudinal axis, seldom in the dorso-ventral axis, but commonly in the transverse axis. The interpretation given is that determination occurs in these three axes in this same order. In *Tachycines* Krause (1934) reports a correlation between the type of mechanical injury to the germ band and the effect. Frontal fissures give duplications in the dorso-ventral axis, median and oblique fissures of various extents and positions give symmetrical or asymmetrical, transverse anterior or posterior duplications or parallel twins (division of differentiation center?), and fine splits give duplications of single organs. Effects produced by operating at different stages show that determination of the main axes is followed by determination of segments

in the longitudinal axis, then of the lateral halves within these segments, and finally of individual organs. Oka (1934) reports preliminary experiments showing only that the egg of the cricket is of the regulative type.

An interesting observation is made by Cappe de Baillon (1925, 1927). Because he has shown that "double monsters" of phasmids (Orthoptera) most probably originate from the fusion of two eggs, he suggests that the oöcytes were partially determined before fusion so that the determined parts of the cortical layer did not fuse completely into a single embryo. He reports that the chance of any given organ being double is correlated with its nearness to the procephalic lobes—the more anterior the more frequently double. This suggests to us that the determination process in the cortical layer of the growing oöcyte begins at or near the anterior end and proceeds posteriorly, the great regulative power of the indeterminate egg permitting fusion of the less determined regulative power of the indeterminate egg permitting fusion of the less determined parts (posterior regions) but not of the more determined parts (anterior regions). Naturally the reverse is true for the experimental production of twins and duplications. An alternative view would consider this the result of the incomplete or dissimilarly oriented fusion of two differentiation centers (Schleip 1929).

Slifer (1934) shows that dechorionated grasshopper embryos can withstand a lowering or 10 per cent or raising of 30 per cent of the osmotic pressure without noticeable effect. A 0.3n Ringer's solution has about the same severity of effect as a 3n Ringer's, but embryos will survive many hours in both and in even more anisotonic solutions. Within certain limits the changes are quickly reversible on return to normal Ringer's. Comparison with *Drosophila* suggests that this may be another criterion of indeterminacy.

**Incompletely determinate eggs** are intermediate between the two extreme types. They are capable of considerable regulation following experimental interference in early stages, but the power is lost much sooner than in indeterminate eggs. Dwarf-formations has been observed but not duplication of parts. The absence of duplications indicates that strict determination of the presumptive anlagen occurs early.

In the Hymenoptera Schnetter (1934b) reports that constricting the Honey Bee egg at the stage of the "uniform blastoderm" (12 hour embryo) can result in a normal dwarf embryo. Later blastoderm stages (24 hour embryo) are less labile and more inclined to mosaic formation with a shift in the regions of different prospective significance (Fig. 2). In the ant *Camponotus* Reith (1931b, 1932b) shows by cauterization and constriction that the egg possesses considerable regulative power until the completion of the visible zonation by differential thickening of the cortical layer (presumably under influence of the activation center). After that it is determinate though not as highly so as dipterous eggs. By centrifuging he shows that stratification of the egg parts prior to the cortical zonation blocks development but later centrifuging does not prevent formation of a fairly normal germ band. These two sets of data show that within this order there is a difference in the time of determination, that of the ant occurring noticeably earlier than that of the Honey Bee. Though there are no experimental data involved, polyembryony (the production of two or more, sometimes several hundred, embryos from a single ovum by division of the cleavage cells into groups) in parasitic Hymenoptera must be viewed as positive evidence of a high degree of regulative power.

In the beetle *Bruchus* Brauer & Taylor (1934) show by constriction and cauterization that determination occurs quite early, the egg becoming a true mosaic during blastoderm formation. In *Sitona* Reith (1935) reports that the determination process occurs slightly later than in the ant and seemingly at about the same time as in the Honey Bee. In Chrysomelid beetles Hegner (1908, 1909, 1911) performed a series of experiments using puncturing, cauterization and centrifugation but his results seem open to some question, partly due to the extreme nature of injury inflicted upon the egg. He claims that when the germ-tract determinant region or the 'pole cells' are removed or killed no germ cells are found in the larva (this seems probable, see Section X), and that the egg shows no regulation during cleavage, blastoderm or later stages, i.e., that it is strictly mosaic from the time of laying. Some of the results of centrifuging these eggs resemble those obtained with *Camponotus*, normal embryos (sometimes displaced) de-

veloping only in eggs centrifuged during the blastoderm stage or later, though one centrifuged female *Leptinotarsa* laid stratified eggs which developed normally. In all these beetles the investigators agree in saying the eggs are completely determined (mosaic) after the formation of the blastoderm.

**Determinate eggs** have been found only in the Diptera but at least as far as the germ cells are concerned Hegner's results indicate that the Chrysomelid beetles might also be placed here (and also the other insects in which the presumptive germ cells are segregated as 'pole cells' during blastoderm formation). Determinate eggs always give mosaic formations under experimental conditions, the few slight exceptions showing an extremely small amount of regulative power. Accordingly the parts of the embryo must be looked on as entirely self-differentiating after fertilization, or, at least, incapable of development beyond their prospective significance.

Reith (1925), Pauli (1927) and Howland & Robertson (1934) report that cauterization of dipterous eggs invariably gives mosaic development. Slight regulative power is shown by Reith's report that the midgut anlagen of either end may form an entire midgut, and also by Strasburger's (1934) report that slight cauterizations at the beginning of cleavage may delay the migration of the cleavage nuclei to the posterior part of the egg without preventing formation of a normal embryo—the posterior parts developing slightly later than the anterior parts. Sonnenblick (1934) and Howland & Child (1935) show that puncturing does not necessarily prevent the development of normal embryos and larvæ although the adults may exhibit injuries. The high mortality and uncertainty as to the exact nature of the extruded materials make their data difficult to interpret under this section. On a basis of ultra-violet irradiation of oriented *Drosophila* eggs Geigy (1931b) postulates two determination periods in the eggs of higher Diptera: (1) an embryonic determination process completed not later than the time of fertilization, and (2) an adult determination process *via* the presumptive imaginal discs in later embryonic life. This will be discussed later.

Howland & Robertson (1934) report that dechorionated *Drosophila* eggs develop normally in "sea water diluted with tap



water to 33 per cent.” They do not mention the effects of other solutions or concentrations but Howland (1932) reported that *Drosophila* sperm are highly sensitive to the constitution of the medium. The solution used for eggs is the same as that she found most satisfactory for sperm.

*Cytoplasmic determination:* It is evident that the distinction between ‘regulative’ and ‘mosaic’ eggs in insects, as in other groups, is not sharp, and the designations mean little unless the period of development is specified. The earlier an egg assumes a mosaic nature the ‘more determinate’ it is, but even the most ‘indeterminate’ of insect eggs eventually becomes ‘determinate.’ Sections V and VI show also that the primary seat of the chemo-differentiation (predetermination) is the cytoplasm as a whole, and that the formation of cells plays only a secondary or indirect part. The fact that development is less disturbed by late than by early centrifuging (Hegner 1909, Pauli 1927, Reith 1932b) suggests that fixation of determination is accompanied by increased cytoplasmic rigidity (viscosity) either before or after cell-formation.

## VII. DEVELOPMENTAL CENTERS

### A. The Activation Center

Seidel (1929b) has used the term “Bildungszentrum” to designate a region situated near the posterior pole of the egg and necessary for development. As we shall show this center is responsible for the activation of the egg system, and so it is here designed ‘the activation center.’<sup>6</sup> The literal translation, ‘formative center,’ is ambiguous and may carry unwarranted implications. It is not a visibly distinct part of the egg but can be more or less closely delimited by experiments. It functions by the production of some substance which diffuses forward through the interior of the egg and initiates development. In its absence no true differentiation of the embryo occurs. To date it has been demonstrated in five species of insects (a damsel fly, two ants and two beetles).

The activation center has been most elaborately analyzed in the damsel fly *Platycnemis* by Seidel (1926–1934). In this species (Fig. 1) the anterior border of the activation center coincides

<sup>6</sup> This term has already been used by Huxley & DeBeer (1934).

approximately with the presumptive posterior end of the embryo (about  $1/9$ th the length of the egg from the posterior pole) but its posterior extent is undetermined. The point at which the germ band later invaginates into the yolk marks its locus (see Section VIII). Here the functioning of the activation center depends upon an interaction between the cleavage nuclei and the region of this center. This is demonstrated by numerous experiments:

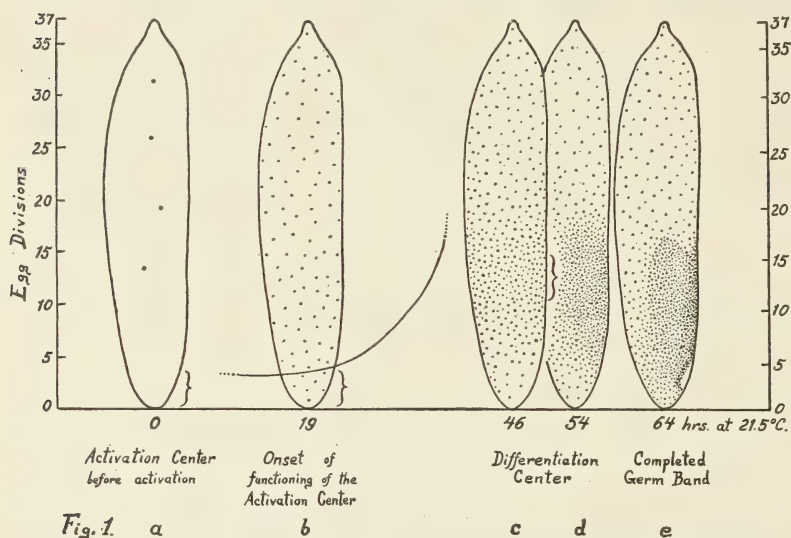


Figure 1. Graphic diagram of the development of the egg of the damselfly *Platynemesis*. *a* 4-nuclei stage with bracket indicating the position of the activation center. *b* 256-nuclei stage with curved line indicating the diffusion anteriorly of the product of the activation center. *c* Beginning of cell-aggregation with bracket indicating the position of the differentiation center. *d-e* Formation and completion of the embryo anlage. 1 egg division equals 24  $\mu$ . (After Seidel, 1934.)

when the cleavage nuclei are late in reaching this region either due to abnormal distribution, killing of one of the first two cleavage nuclei with ultra-violet light, or constricting the egg and later removing the constriction, the functioning of this center is delayed. Careful comparison with normals shows that none of these delays causes any effect on later development other than delaying the onset. If, however, the cleavage nuclei are prevented from entering this region by a constriction of the egg no

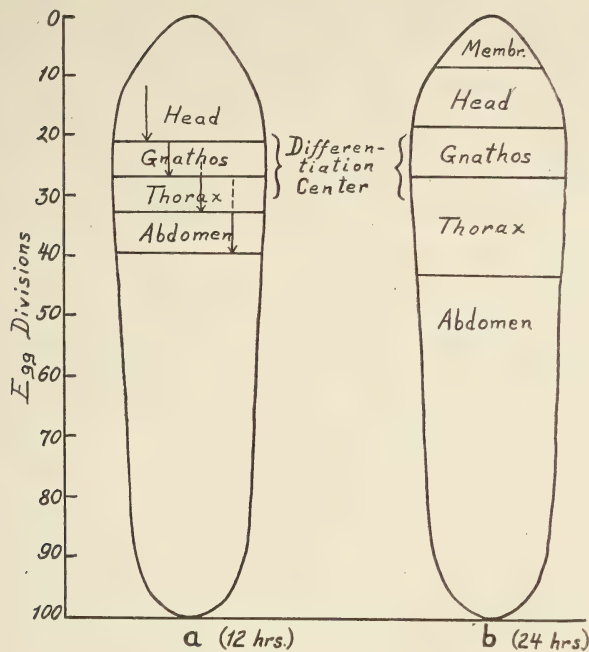


Fig. 2. (After Seidel)

Figure 2. Schematic Anlagen plan of the Honey Bee egg. *a* Posterior boundaries of the *potency regions* ("... those regions of which a small part must remain in the egg to enable the formation of the entire corresponding organ region") in the 12-hour blastoderm. *b* Expansion of the same regions along the longitudinal axis in the 24-hour blastoderm. (After Schnetter, 1934b.)

development ensues although the anterior parts continue to live, undergo 'yolk cleavage' and eventually form an extra-embryonic blastoderm. Partial constrictions show clearly that it is the nuclei which must reach this area, not some chemical which can diffuse through the yolk system. The reaction is not limited to the surface of the egg (which lacks a distinct cortical layer) since peripheral parts in the region of the center may be killed by ultra-violet light without preventing normal development. Finally, the removal of constrictions and constricting after the nuclei enter this region both show by the production of embryos that the injury to the egg does not block development. There-

fore we must conclude (1) that the egg contains two quantitatively or qualitatively different regions (compare animal and vegetal poles of other eggs), and (2) that neither the cleavage nuclei and their cytoplasm nor the activation center is capable of producing a normal or even partial embryo alone, but that they react together to furnish a product which allows normal development to proceed along axial and symmetrical lines that have already been laid down.

Seidel further shows that after the nuclei have entered this region, more and more can be constricted off from the posterior end of the egg without blocking development. The action of the center spreads slowly over a considerable area so that well before the assembling of cells to form the germ band its effect has been felt over the entire presumptive germ band (see curved line in Fig. 1). The interaction product must diffuse forward through the yolk system since a partial constriction after the nuclei reach the activation center does not prevent an embryo being formed anterior to the constriction. In some eggs there is a visible change in the structure of the yolk proceeding apace with the diffusion of factors from the posterior pole anteriorly. Further, this product activates the differentiation center which will be discussed below.

In the ant *Camponotus* Reith (1931, 1932) shows by constriction and cauterization that an activation center is present near the posterior pole but he has not delimited it closely. In this species it differs from *Platynemesis* in that the cleavage nuclei are not responsible or even necessary for its functioning. Its activation must be induced by some product concerned in fertilization, presumably produced not later than the time of fusion of the egg and sperm nucleus since the visible effect of the functioning of the activation center is seen in very early cleavage stages. This product must diffuse through the yolk system just as the product of the activation center does since neither is impeded by partial constrictions, yet obviously they cannot be the same substance. Another interesting difference from *Platynemesis* is that the activation center in this species induces a visible zonation (differential thickening) of the cortical layer prior to the migration of the cleavage nuclei. This visible differentiation begins at



the posterior pole and passes slowly to the anterior end of the egg as does also the 'activating power.' Attempting to localize the activation center to some visibly distinct part of the posterior region of the egg he noted that the disintegration of the 'pole-disc' is correlated with the action of this center. The 'pole-disc,' however, can not be the essence of the center since it is lacking in the ant *Lasius* which gives similar experimental results. Nor can the effect be traced to the bacterial symbionts since their injury is not correlated with that of the embryo. [It is interesting to note that Hinman (1932) shows various bacteria present in a small percentage of mosquito eggs without seeming effect on the embryos, and Scheinert (1933) discusses their presence and perpetuation in various insects.] As in *Platynemis*, the activation center must be ascribed to an invisible difference in the egg regions.

In the beetles *Bruchus* and *Sitona* Brauer & Taylor (1934) and Reith (1935) report the presence of an activation center in the posterior region of the egg. In both of these beetles the functioning of this center begins during cleavage and is finished when the nuclei enter the cortical layer (*i.e.*, later than in ants). Unfortunately these are both rather preliminary reports and analyses must be made with care. In *Bruchus* Brauer & Taylor report that when the constriction is made sufficiently early to exclude nuclei from the posterior end of the egg, the anterior portion forms "only a poorly developed blastoderm," yet "a protoplasmic isthmus . . ., however narrow it may be, serves to conduct the organizing principle anteriorly." Hence it would seem that the nuclei are necessary for the functioning of the activation center in *Bruchus* as in *Platynemis*.

### B. The Differentiation Center

The visible differentiation of the insect embryo begins in the presumptive prothorax, and from this region proceeds anteriorly and posteriorly. Descriptive embryology shows that the spread of differentiation from the thoracic region is a general principle of insect development,<sup>7</sup> and, as Schnetter (1934a) points out, may

<sup>7</sup> Schnetter (1934a, table 12) gives a comparative table including representatives of all the major orders.

be considered as typical of insects as is superficial cleavage, though there may be exceptions in regard to both (in other arthropods and annelids, differentiation begins in the head). There is evidence that this also applies to pupal development. Seidel speaks of "das morphologische Differenzierungszentrum" and "das physiologische Differenzierungszentrum," but since these two terms denote distinct concepts it is deemed preferable in this paper to avoid this terminology, although, in general, Seidel's treatment is followed. The term 'differentiation center' is here restricted to a physiological concept and is not applied to the visible starting point of differentiation, even though physiological and morphological phenomena normally occurring at a common locus may at times appear to be experimentally separable.

In *Platycnemis* the region where the two rows of assembled nuclei first come together to form the germ band marks the place from which all later differentiation proceeds anteriorly and posteriorly; it lies in the presumptive thoracic region, about one-third the length of the egg from the posterior pole (Seidel 1926, 1929b, 1934). In the Honey Bee (Schnetter 1934a) the visible embryonic differentiation begins near the anterior end of the egg (presumptive cervical region) at the site of polar-body formation, where the cortical layer is thickest, reticular cytoplasm is most concentrated, cleavage nuclei become most numerous and first reach the surface, vitellophags first appear, heterochronous mitoses first set in, and cell-partitions are first formed. A qualitative distinction of this region during cleavage is indicated by differential staining with thionin but not with haematoxylin. This region also has precedence in all later differentiation (formation and closure of mesodermal furrows, segmentation, appearance of appendages, etc.). A similar region is evident in *Ephesia* (Sehl 1931) but here the proctodæum forms before the stomodæum, 'yolk cleavage' progresses from posterior to anterior, and dorsal closure of the body wall is completely last on the mesometathoracic boundary. Eastham (1927) describes the differentiation processes in *Pieris* as occurring "from before backwards." Spread of morphological differentiation from a definite region is not so evident in the eggs of higher Diptera.

Experimental methods have demonstrated, as one might expect, that this region of initial morphological differentiation is of fun-

damental physiological significance, incorporating the so-called 'differentiation center.' The results of constricting *Platynemís* eggs (Seidel 1934) show that this center normally coincides with the starting point of morphological differentiation though seemingly this morphological manifestation can be experimentally separated from the primary physiological center. The differentiation center extends from the second gnathal (maxillary) segment to the second thoracic segment with its midpoint in the anterior half of the presumptive prothorax (Fig. 1c, 4a).

Seidel (1929b, 1931, 1934) further shows that no differentiation can occur in an isolated region of the egg of *Platynemís* unless the differentiation center is present in whole or in part. The center can function only after the product of the activation center has reached it by diffusion. It does not affect blastoderm formation but does directly influence the assembling of blastoderm nuclei and heterochronous divisions in germ band formation, although heterochronous divisions alone occur when almost the entire center is tied off. Unlike the activation center, the differentiation center cannot function normally with even a relatively slight constriction of this region of the egg. A very loose ligature outside the boundaries of this center will allow the formation of the germ band on both sides of the ligature, but if it is only slightly tighter, even though the blastoderm and yolk remain unsevered, the germ band forms on one side only. Since no continuity is destroyed in any part of the egg by such a constriction, the center's action cannot depend solely upon the spread of a substance but must involve an energy transfer, *i.e.*, must be a dynamic phenomenon. Cell aggregation to form the germ band is not prevented by killing a complete girdle of blastoderm cells over the entire region of the center (by ultra-violet irradiation). Initiation of this process must therefore originate in the 'yolk system,' viz., the yolk with its included cytoplasmic reticulum and vitellophags. Localized contractions of the surface of the yolk system, produced by cautery or point-irradiation before or during the time of cell aggregation, result in changes in the length, shape and position of the embryonic rudiment. The spaces between the yolk and chorion thus formed, or resulting when a ligature is loosened, serve as foci for cell aggregation which can thus be

artificially and prematurely produced outside the normal region. These data indicate that the direct action of the differentiation center is due to a wave of contraction in the yolk system spreading anteriorly and posteriorly from the center, the yolk system retracting from the chorion in such a way that the evenly distributed blastoderm cells are forced to fill the resulting space. In this manner cells first aggregate in the region of the differentiation center, and the size and shape of the germ band is molded by the space between yolk and chorion. This makes it clear how the differentiation center can be the center of a field of activity without necessarily involving the actual transport of any material substance, the result of constructions being due to interference with yolk movements. Additional proof of the dynamic nature of the differentiation processes in *Platynemís* is furnished by the fact that killing a girdle of cells by ultra-violet irradiation either in front of or behind this region where visible differentiation normally begins causes a corresponding shift (backwards or forwards respectively) of the position of the initial differentiation. The yolk system is in effect temporarily reduced in size and the visible differentiation begins in the same relative position within the new system that it held in the larger system. If, then, the differentiation center is a definite region within the egg (as it seems to be), it must remain at one end of the reduced system while its action originates in a new location.

In the Camel Cricket *Tachycines* (Krause 1934) the order of decreasing regulation ability (lost earliest by the thorax), the relative frequency of organ-duplications (least often in prothorax), and certain asymmetrical duplications show that differentiation along both longitudinal and transverse axes proceeds anteriorly and posteriorly from the first thoracic segment. He suggests that the presence of a differentiation center may account for the non-occurrence of doubling along the longitudinal axis.

The results of constricting eggs at successive points along their length enabled Schnetter (1934b) to mark off 'potency regions' in the 12-hour blastoderm of the Honey Bee egg. Each of these regions when present in whole or in part guarantees the *complete formation* of the corresponding embryonic systems (*cf.* 'harmonic equipotential regions,' *e.g.*, limb-field in amphibia). Thus regu-



lation in the Honey Bee egg is, in general, 'stepwise,' a given region developing as a whole or not at all. In fig. 2a it can be seen that all the potency regions lie within or extend into the region of the differentiation center. Accordingly it may be regarded as a "concentration center" for potencies enabling whole-formation of the various organ regions. Fig. 2b shows that there is a shift of these potency regions during the time between the 12- and 24-hour blastoderm. This, with a few preliminary experiments on an intermediate stage, indicates that there is a gradual shifting of these boundaries out of the differentiation center and into their definitive position. These facts suggest that the differentiation center bears a causal relation to the development of the embryonic regions. The fact that a fixed (morphological) region of the bee egg may have a prospective potency in an early stage that is entirely different from (not merely more extensive than) its prospective significance as shown in a later stage, indicates that chemo-differentiation is not only progressively increasing as development proceeds but that there is also occurring a *redistribution* of the chemo-differentiated materials. Further a shift in the region of first visible differentiation in developing dwarfs following constrictions in the 12-hour stage (as evidenced by the more posterior position of the beginning of the mesodermal furrows) indicates that this point assumes about the same relative position in the decreased whole as in a normal egg. So presumably dynamic factors are of fundamental importance in the egg of the Honey Bee as well as *Platynemís*.

In the ant *Camponotus* Reith (1931b) noticed that defects resulting from late cauterization of the presumptive anlage-region suggested a dependence of the posterior regions upon the anterior for normal differentiation. He reports two cases in which defects at the anterior end of the germ band resulted in the absence of differentiation although the nuclei migrated normally. Presumably these represent an elimination of the differentiation center.

In the beetle *Sitona* Reith (1935) reports admittedly incomplete experiments indicating the presence of a differentiation center located in the central region of the egg. This center seems to be stimulated by the activation center since no development occurs when the latter is destroyed during cleavage. He says that by

analogy with *Platynemís* and the Honey Bee this center must be assigned a "regulative" significance.

In the higher Diptera the data from cauterization, constriction and centrifugation (Reith 1925, Pauli 1927, Rostand 1927, Strasburger 1934) show that in all cases mosaic or partial embryos are produced by elimination of any egg part irrespective of the age of the embryo. A physiological differentiation center affecting larval organization is not demonstrable although Henshaw's data (1934) indicate that there is some physiological regulator of early embryonic differentiation in *Drosophila* since only weak doses of x-rays were required to block development before gastrulation but much stronger doses were required later. Also, Geigy reports (1931b) that in the production of defective adults of *Drosophila* by ultra-violet irradiation of eggs, both the sensitization and desensitization to the rays begins in the thorax and proceeds posteriorly as a function of age. This is seemingly to be interpreted as a differentiation center in the presumptive adult thorax, the effect of which passes progressively posteriorly, even though no such center has been demonstrated for larval organization.

### *C. Interaction of Centers and Other Regions of the Egg*

Seidel (1934) has shown that in *Platynemís* an interaction between the cleavage nuclei and the region called the activation center results in a product which diffuses forward in the egg (see Fig. 1 a-b). As this product passes anteriorly there is a visible change in the structure of the yolk preceding space with the diffusion. However, this product does not directly affect differentiation; it functions by the activation of the differentiation center. The latter, in turn, appears to induce the onset of heterochronous cell divisions and the contraction of the yolk system which brings about the aggregation of cells to form the germ band and the later shift in the position of the same.

Comparison of the reactions of the activation center and differentiation center of *Platynemís* under similar restrictions indicates that they differ in mode of action. A loose or temporary constriction in the region of the activation center results in no abnormality but only delay. But a loose or temporary constriction in the region of the differentiation center (after functioning

of the activation center) invariably results in an abnormal embryo. This is elucidated by proof that the first functions by the production and diffusion of a specific material substance, the second by dynamic movement processes which must have some as yet unknown physico-chemical basis.

The realization of the importance of dynamic phenomena in development has enabled further analysis of the processes underlying determination and regulation and of the significance of the 'centers.' Such an analysis, based primarily on his findings in *Platynemís*, has been begun by Seidel (1934). The predominant notes in his discussion are the importance of the entire egg as a substrate for dynamic processes in determination, the subordination of the so-called 'centers' to the system as a whole, and the alternation of dynamic processes and "material reactions" during development. The latter is quite evident in the sequence of events in *Platynemís*, viz., the migration of cleavage nuclei, the reaction between nuclear and cytoplasmic factors in the activation center, the diffusion of the reaction products cephalad from the activation center, reaction with the yolk system, and the contraction of the yolk system originating in the region of the differentiation center. The determination process is carried out by this alternating series of dynamic processes and material reactions, the former involving the egg system as a whole and enabling the reactions of more or less delimited substances and structures, the centers, to take place. In this light, regulation is not dependent upon the powers of definite centers but upon dynamic processes or structures made possible through such processes. It follows that regulative ability is limited by the degree of rigidity of the arrangement of all the substances and structures necessary for development. Regulation can occur only in that part of the egg in which normal dynamic processes can transpire, and the degree of regulation depends upon the extent to which they can proceed unhampered. As Seidel says, the entire egg must be regarded as a system in which not only the embryonic tissues and included factors but also the extra-embryonic parts must be held responsible for the determination of the organ-regions.

In no other group is there a set of data for any one species sufficiently extensive to permit such a complete analysis of factor

interaction. Reith (1931, 1932, 1935) shows an activation center at the posterior end of the egg of the ant and weevil. The action of its product is similar to that in the damsel fly but the onset of its action is not dependent on the entrance of cleavage nuclei into the region but is initiated presumably by some part or product of fertilization. However, in the beetle *Bruchus* Brauer & Taylor (1934) give a brief report indicating that the cleavage nuclei are necessary for the action of the activation center. Schnetter (1934b) was unable to demonstrate an activation center in the Honey Bee egg but he has shown the presence of a differentiation center which seems to bear a causal relation to the development of the embryonic rudiment. These data, while differing in certain details from the damsel fly, indicate that dynamic factors are responsible for the arrangement of the structural elements, since regulation involves a shift in the site of initial differentiation along with that of the potency regions. The more rigid the system, the less the regulative power—a principle which may involve the viscosity of the cytoplasm as suggested by the results of centrifuging the eggs of other insects (Section VI). In these insects, also, determination is probably brought about by a harmonious series of interacting processes.

In the determinate type of egg (Reith 1925, Pauli 1927, Sturtevant 1929) we must assume that the determination attained by such series of events is in large measure completed by the time of fertilization so that the various egg regions are 'self-differentiating.'

#### *D. Comparison of Insects and Amphibia*

In drawing a general comparison between insect and amphibian development, Seidel (1934) regards both the insectan differentiation center and the amphibian organizer as "factor regions" of which the ability to function is subordinate to the dynamic processes of the entire egg. In both, regulation is effected not through the developmental centers but through the system as a whole which the centers subserve. Fundamentally the determination processes in the two groups may be similar, but he adds that more detailed comparison must await further analysis of the causal relation of the insectan differentiation center to organ for-



mation. Evidence from the Honey Bee (Schnetter 1934b) indicates a similarity between the differentiation center and the organizer, in that the former is a concentration center for potencies enabling regional differentiation along the entire length of the egg, and the latter seems also to possess individuation factors.

Seidel also compares the action of the insectan activation center with the action of the inducing substance of the amphibian organizer. In *Platycnemis*, after the cleavage nuclei migrate into and react with the activation center, a substance diffuses forward through the yolk. In Amphibia, the organizer region (chordamesoderm) is carried under the ectoderm by the process of gastrulation, and the inducing substance reaches the overlying layer by direct contact. Interaction in the sense of an underlying layer influencing an overlying layer has not been demonstrated in insects.<sup>8</sup> In both insects and amphibia dynamic processes are instrumental in bringing the inducing substance to its field of action where it is the precursor of further dynamic processes—contraction of the yolk system in the one case, formation of the medullary tube in the other.

We have omitted two points from Seidel's comparison. First, his statement that any purely chemical hypothesis of the primary action of the differentiation center is improbable. This is based on the observation that aggregation to form the germ band depends on a contraction wave in the yolk system, and any constriction which interferes with this contraction results in an abnormal embryo. The nature of the origin of this contraction wave is unknown, and in the light of recent work on the chemical nature of the amphibian organizer it seems advisable to leave this question open, though, as Weiss (1935) points out, the 'chemical organizer' is really only an activator, not an organizer. Second, Seidel says that the principal difference between the amphibian organizer and the insectan differentiation center is that the former lays down a dorsal anlage, the latter a ventral anlage. We wonder if this is not as fundamental a similarity as difference since, in both, the embryo forms on that side of the egg which will give rise to the nervous system.

<sup>8</sup> Although metamerism is usually first evident in the mesoderm, there are several cases reported (*e.g.*, *Pieris*, Eastham, 1927) in which it is visible in the ectoderm before in the mesoderm.

Aside from Seidel's discussion, it may be noted that the activation center of the insect egg is similar to the amphibian organizer in (1) its location, (2) its activation in some species by fertilization or some concurrent phenomenon (*e. g. Camponotus*) although in certain species (*e. g. Platynemis*) the cleavage nuclei are necessary for its functioning, (3) its functioning by the production of a specific substance, and (4) this substance in turn activating or establishing a second center (the differentiation center) which then directs development by dynamic phenomena. There is a paucity of data regarding causal relationships of the developmental centers to organ formation but this is also Seidel's principal reason for refraining from a definite analogy of the insectan differentiation center with the amphibian organizer.<sup>9</sup> The comparison leads inevitably to the question as to whether the differentiation center is to be considered a primary developmental center which is merely activated by the product of the activation center, or a secondary center produced by the activation center or by factors involving the egg as a whole. Seidel favors the former interpretation, but from the available data it seems that the latter is possible. Some of the observed effects of reducing the yolk system by partially constricting the egg of *Platynemis* could also be explained by postulating that there is a certain minimum size to which the system can be reduced before it becomes incapable of producing the contraction wave leading to germ-band formation. Tying off the original locus of the differentiation center may be simply reducing the system so much that the forces concerned cannot bring about the simulation of the normal visible processes. In this light the differentiation center would be a focal point of forces—an effect, rather than a fixed region of causal factors. However, the production of partial embryos by complete constriction is possible evidence that the differentiation center may be a fixed region of potency factors. It seems that the exact nature of the differentiation center can be decided only by experiments analogous to the extirpation and explantation of organizer material in Amphibia. In this connection Weiss (1935) makes the illuminating suggestion that the activating and

<sup>9</sup> The only insect in which any causal relationship of the differentiation center to organ formation is known (Honey Bee) is one in which we know nothing about the activation center.

organizing functions which are combined in normal amphibian development, are spatially separated into two centers, the activation center and the differentiation center, in normal insect development.

### VIII. BLASTOKINESIS OR MOVEMENTS OF THE EMBRYO

Prior to the differentiation of striated muscle fibers the insect embryo frequently undergoes extensive movements. These movements vary greatly in different insect groups (see Imms 1934 or Snodgrass 1935). They have been experimentally studied in the grasshopper *Melanoplus*. Here blastokinesis consists of a reversing of the longitudinal axis followed by a revolution around this axis. Slifer (1932a) shows that this change of position is accomplished by vigorous movements of the embryo itself. These movements originate as contraction waves running along the lateral borders of the dorsally-incomplete abdomen and passing rapidly to the head. With the closure of the dorsal wall and the formation of the dorsal vessel they seem to become resolved into the heart beat as was suggested by Nelsen (1931). In overwintering eggs, diapause interrupts incipient blastokinesis as well as an other developmental activities, these processes being resumed immediately after the end of the diapause period (diapause will be treated in Part II).

Although the embryonic membranes are usually ruptured Slifer reports one positive case in which blastokinesis was initiated and partly completed without the rupture of the serosa, showing that the contraction of the embryonic membranes cannot be the primary cause of revolution. Hence, in the grasshopper, the revolution of the embryo must be due to its own movements. In sections of embryos of this age she (1934) found unicellular, non-striated, spindle-shaped fibers in the position of the future abdominal muscles. She suggests that these cause the movements (striated muscles do not appear until nine days later).

Concerning the necessity of revolution Slifer (1932a) reports four cases in which it failed to occur and yet the embryos developed more or less normally but were incapable of hatching. But Tirelli (1931) reports that the occasional failure of blastokinesis

in the Silk Worm egg invariably results in death. However, in the latter case blastokinesis brings the dorsal surface of the embryo into a spatially and mechanically more favorable position whereas no apparent advantage is attained in the grasshopper. In *Platynemis* Seidel (1929b) reports that prevention of blastokinesis by constriction seemingly inhibits development of a posterior part embryo beyond the differentiation of the organ systems, while if the anterior part of the embryo develops in front of an incomplete constriction, blastokinesis occurs in that part of the egg and histological differentiation is completed. Accordingly it seems that blastokinesis is prerequisite for the completion of development in *Platynemis*.

Although not usually classed under blastokinesis we include here the report of Child & Howland (1933) that the migration of the germ cells of *Drosophila* from the posterior pole of the egg to the dorsal surface and thence to the interior of the embryo seems due to the force exerted by the rapid upward growth of the ventral blastoderm. They add that the subject needs further study.

## IX. THE ANLAGEN PLAN OF THE EMBRYO

The only satisfactory worked-out anlagen plan of any indeterminate or incompletely determinate type of insect egg is that given by Seidel (1935) for *Platynemis*. This is well shown in Fig. 3 which gives the blastoderm plan from all three views, and in Fig. 4 which shows the changes undergone during the formation of the embryo. The first phase of shortening of the embryo occurs simultaneously with the onset of action of the differentiation center (Fig. 4 a-b). During this time the presumptive head and abdominal regions contract while the thoracic region increases in length as a result of two movement-tendencies, one drawing the materials towards the region of the differentiation center (between the gnathal and thoracic anlagen), the other drawing the entire presumptive embryo towards the posterior end of the egg. The two tendencies coincide in front of the differentiation center but are opposed posterior to it. In the second phase of shortening (Fig. 4 b-c) the head and gnathal anlagen expand while the thorax and abdomen shorten. During this



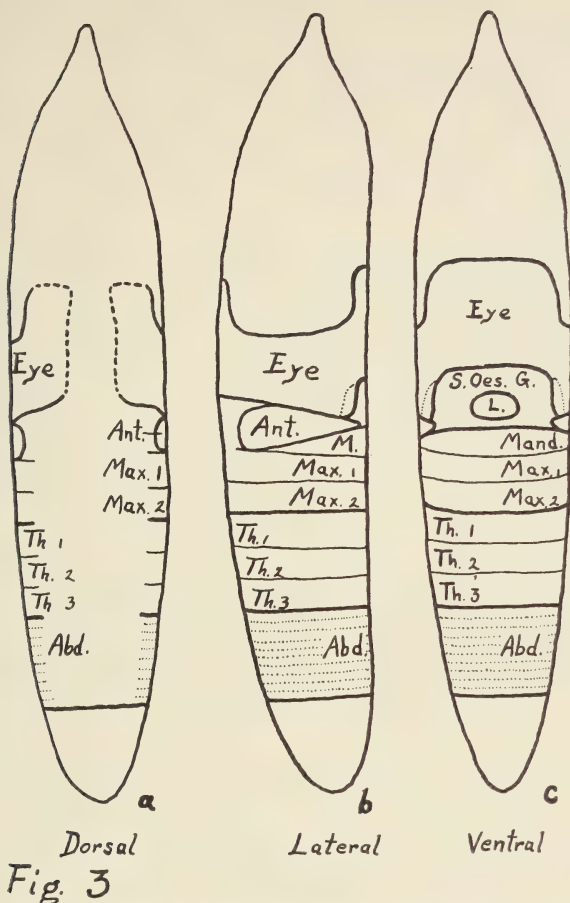


Figure 3. Plan of the presumptive organ anlagen for the blastoderm stage. *a* dorsal side of egg, *b* left side, *c* ventral side. The numbers indicate the divisions of the egg (1 division equals  $24\mu$ ). *Abd* abdomen anlage, *Ant* antenna anlage, *Eye* Eye anlage, *L* labrum anlage, *Mand* mandible anlage, *Max* 1-2 maxillae anlagen, *Th* 1-3 thoracic segment anlagen, *S.Oes.G.* Supraoesophageal ganglion anlage. (After Seidel, 1935.)

phase the action of the differentiation center is no longer apparent. The entire embryo continues to move posteriorly and soon invaginates into the yolk. During and immediately following invagination the parts of the embryo elongate and assume larval proportions.

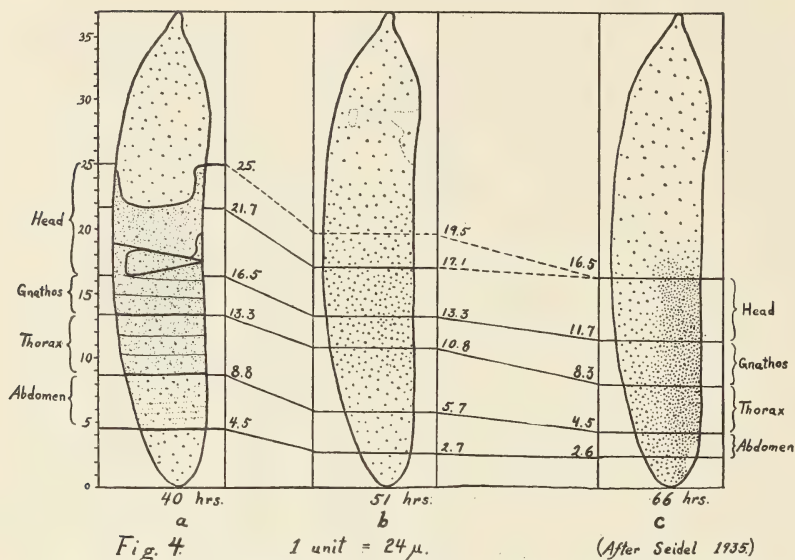


Figure 4. Graphic representation of the shifting of the anlage regions of the left side of the egg in reference to the movement of cell-nuclei. *a* Blastoderm stage through *b*, cell aggregation to form the germ band, to *c*, the completed embryo anlage. Abscissa: Time in hours after the 2-nuclei stage. Ordinate: Number of divisions from the posterior pole of the egg (1 division equals 24 μ). (After Seidel, 1935.)

From Seidel's detailed discussion of irradiation defects as marks in making these maps we note the following: (1) The study is hindered by regulation processes. (2) Raising the temperature accelerates the differentiation process more than the healing process and so aids the formation of defects. (3) For certain organs the experiments show a 'defect correlation' rather than a 'developmental correlation.' For instance there is a high correlation of eye and thoracic defects which Seidel suggests may be due to a primary defect changing yolk contraction and thereby altering the molding of the embryonic anlage. (4) Defect experiments do not show the true morphological course of development owing to the indirectness of physiological investigation; more truly they indicate a plan of the various factor regions.

Schnetter (1934b) gives a partial segmental map of the 12- and 24-hour blastoderm of the Honey Bee egg (Fig. 2) showing

a shift in the prospective significance of the parts of the blastoderm between these two stages. Incidentally he says that after the formation of the germ band the differentiation center no longer belongs to the structure of the whole egg but only to the embryo. With the shift of the presumptive embryonic parts the middle of the differentiation center shifts from division 24 of the egg to division 28.

For the determinate (mosaic) egg of the Diptera Reith (1925) and Pauli (1927) show that the parts of the embryo originate as presumptive anlagen at the same points where they later make their appearance, and that little or no regulation occurs. Sonnenblick (1934) and Howland & Child (1935) report that normal larvæ and adults may develop from punctured *Drosophila* eggs from which a portion of the contents has been extruded. Due to doubt as to the exact nature of this extruded material it is not possible to evaluate these results. However, Sturtevant (1929) shows by genetic analysis of *Drosophila* gynandromorphs that the presumptive imaginal discs must occupy the same relative positions in the blastoderm as the points where they later make their appearance in the larva. As healing processes are not involved in this case it seems that a shift in prospective significances such as Schnetters describes for the Honey Bee does not occur in *Drosophila*.

## X. ORGAN FORMATION

1. **Endoderm:** There are no really pertinent experimental data. The midgut is clearly not the primitive archenteron. It is formed, practically regenerated, later in development from rudiments. Eastham (1927) and Snodgrass (1935) review the subject from a comparative-morphological standpoint. The principal difficulty arises from the fact that in some insects the lining of the midgut arises from mesenteron rudiments carried in on the tips of the stomodæal and proctodæal invaginations, whereas in other insects this lining is produced by proliferation from the tips of *unilaminar* stomodæal and proctodæal invaginations. Eastman (1927) and Richards (1932) have suggested that this is only a difference in the time of determination of the functional endoderm. Using maps of prospective significance Richards illus-

trates the difficulty encountered if we consider the functional endoderm as determined before its growth into the definitive midgut in forms in which it arises by proliferation from the unilaminar tips of the stomodæal and proctodæal invaginations. He suggests that in such forms it is not determined before this time and that its determination must be a function of the position of the cells concerned.

Reith (1925) reports that the midgut anlagen are practically the only part of the House Fly egg capable of development beyond their prospective significance. In this species more than half of the midgut is formed from one end when either the stomodæal or proctodæal invagination is absent.

2. **Germ Cells:** In certain insects (Honey Bee, moths, etc.) the gonads and presumably also the germ cells originate in the genital ridge of the splanchnic mesoderm. This type has not been studied experimentally during embryonic stages. In certain other insects the germ cells are segregated at the posterior pole of the egg during cleavage (called 'pole cells'). Their further development is more or less independent of the rest of the embryo.

Hegner (1908, 1911) showed that the elimination of the posterior pole from the eggs of Chrysomelid beetles either by pricking and allowing part of the egg contents to flow out or by killing with a hot needle results in an embryo lacking germ cells and possessing certain structural defects. Reith (1925) obtained similar results with the House Fly. Geigy (1931a) reports that killing the posterior pole of *Drosophila* eggs by ultra-violet irradiation during cleavage results in adults whose gonads are composed of only mesodermal elements (*i.e.*, contain no germ cells). Shorter irradiation frequently resulted in unilateral castration. The single gonad might be small, of normal size or larger than normal. To explain these large single gonads he accepts Rupert's suggestion (1924) that in addition to killing some of the cells the ultra-violet rays cause an adhesiveness of the germ cells so that they stick together during migration into the embryo instead of separating into two gonadal groups. More exacting data on *Drosophila* are given by Howland & Robertson (1934). They dechorionated eggs and killed part or all of the 'pole cells' by carefully localized point cauterization. The sole effect was



partial or total sterility. Therefore the 'pole cells' are not only destined to form the definitive germ cells but they are incapable of being regenerated by an otherwise normal embryo.

**3. Imaginal Discs:** This topic will be treated more fully in Part II. By analysis of *Drosophila* gynandromorphs Sturtevant (1929) shows that the cortical layer is not only determined for the parts of the embryo but also (perhaps secondarily) mapped out for the adult *via* the presumptive imaginal discs. Geigy's results (1931b) made it seem that Sturtevant's data were valid only for prospective significances since Geigy obtained imaginal defects only when he irradiated eggs with ultra-violet light after the differentiation of the larval organs had begun. Geigy therefore advanced the idea of two separate determination periods in Diptera, the first for the embryo, the second for the adult. But Smith (1935) reports similar non-hereditary defects from x-rayed female gametes, and thereby leads to our questioning the validity of Geigy's two periods. Perhaps the discrepancy can be traced to the different types of irradiation used but it seems best to leave it an open question.

**4. Duplication of single organs:** These are produced by the same agents that cause duplications of whole parts. They illustrate two points of interest: (1) that any internal organ, including the nervous system, or any external part is capable of duplication separately or in combination with other parts: and (2) that duplications represent a positive new or additional formation in the sense that the sum of the two duplicated parts exceeds the size of a single normal organ. In fact, the size is increased even when the parts 'heal' so that no duplications occur. To date duplications have been produced only in indeterminate types of eggs and the phenomenon is one of the criteria used to distinguish this type of development (Seidel, Krause).

Cappe de Baillon (1927) and von Lengerken (1928) suggest that some duplications may result from the fusion of two oöcytes whose cortical layers are partially determined at the time of fusion. Positive evidence of this is available only in the phasmids (indeterminate type of egg).

**5. Order of embryonic determination:** In addition to the determination process passing anteriorly and posteriorly from

the thoracic differentiation center there is sometimes a later, secondary determination for specific organ characteristics. The data are from intermediates.

To explain intersexes of the Gypsy Moth Goldschmidt (1927, 1931) postulates that the individuals begin development as one sex, that a physiological change constituting a turning point occurs, and that subsequent development is characteristic of the other sex. All structures finally determined before the time of this change will be of the former sex, all determined later will be of the opposite sex. An intersex is then a 'time mosaic' of male and female parts due to differences in the time of determination of specific organ-types (Shull 1930b). In application it is assumed that in the induced change from one sex to the other the order of determination is the reverse of the order of modification in specimens successively more like the opposite sex. Applying this Goldschmidt finds that the sex of the gonads and abdomen are determined before that of the wings and antennæ. One of the most interesting points is that the onset of histological differentiation of the sexual characters does not necessarily signify that the sex of those organs is finally determined. This is clearly shown by the gonads. These may develop to the point of containing almost mature eggs or sperm and then following sex-reversal have the differentiated germ cells degenerate and be replaced by the differentiation of germ cells of the opposite sex. All this occurs because of the genetic constitution of the cells themselves and presumably is not influenced by hormones.

Shull (1930b, 1931) reports that when the offspring of winged females of the aphid *Macrosiphum* are gradually changed from gamic to parthenogenetic type, the differential features of successive offspring change at different times and rates. The first to change are the color of the antennæ and the color and size of the tibial sensoria, then the body color and reproductive system. Within the reproductive system the collateral glands and seminal receptacles change sooner than the ovarioles. However, when the mother is induced to revert to the production of gamic instead of parthenogenetic offspring, this series of changes instead of occurring in the same order occurs in the reverse order contrary to expectations based upon the time of determination hypothesis. This phenomenon remains unexplained.

## XI. SUMMARY

1. The earlier developmental processes in the insect egg have been experimentally studied in species of Orthoptera, Odonata, Coleoptera, Hymenoptera and Diptera. (Section II.)

2. The fundamental processes underlying the determination of polarity and symmetry are unknown. In bilaterally symmetrical eggs, at least, where the main axes are usually coincident with those of the mother, polarity and symmetry must be impressed upon the developing oöcyte, perhaps by extra-oval factors. Secondary influence by the sperm, if any, would be possible only in radially symmetrical eggs. Gravity is not a factor. (Section III.)

3. The phenomena of fertilization are likewise poorly understood. At fertilization eggs are usually in the first meiotic metaphase. In some species the sperm does, in others does not have an activating function. Polyspermy is common. Bi- and trinucleate eggs may develop with correlated effects on the morphology and genetic constitution of the products. Parthenogenesis is widespread and has been induced in some gamic species. (Section IV.)

4. The cleavage nuclei are not restricted as to their destination in the embryo. They divide synchronously for a specific number of divisions but sooner or later heterochronism sets in. They are not the decisive factors in determination and are indeterminate or totipotent at least until the blastoderm stage (except in certain species in which the nuclei entering the germ-tract determinant region are differentiated sooner, and also the vitellophags of certain species). (Section V-A.)

Migration of cleavage nuclei is generally regarded as not autonomous but the result of extrinsic factors in the surrounding egg plasma (flowing or contraction) which are also instrumental in the formation of the inner cortical layer. The origin of these movements is at present a matter of conjecture. (Section V-B.)

Nuclear migration is distinct from blastoderm-cell formation. There is evidence that the latter may be a function of the activation center, predetermined cytoplasm, oöplasmic streaming or nuclear stimulation, these factors varying in importance in different insects. (Section V-C.)

5. Insect eggs may be arranged in a series ranging from indeterminate to determinate types. This series is valid in regard to both the relative time of visible differentiation of the organ anlagen (the sooner visible the more determinate the egg) and the degree of potency or regulative power of the egg parts (greater regulation and later determination in indeterminate eggs). Hence at the time of deposition the egg may be of either the regulative or mosaic type, with subsequent determination in the former occurring either rapidly or gradually and sometimes accompanied by visible differentiation of the unsegmented cytoplasm (the ant). Cell formation probably plays only an indirect role in differentiation. (Section VI.)

6. Two physiological centers may be present in the insect egg: an activation center at the posterior pole and a differentiation center in the presumptive thoracic region. The former has been demonstrated in a damselfly, two beetles and two ants; the latter is probably present in all insects and has been studied in detail in a damselfly and bee.

The activation center confers upon the egg the ability to undergo development, but its rôle in embryonic determination is unknown. It is not morphologically distinct, may or may not require interaction with cleavage nuclei, and releases a substance which spreads anteriorly through the egg. This product seemingly stimulates the differentiation center to function. (Section VII-A.)

The differentiation center normally coincides with the region where differentiation of the embryonic rudiment begins in the presumptive thoracic region. Reduction of the size of the egg system results in a displacement of the region of first visible differentiation to a position relative to the new whole, but the physiological center is seemingly retained at its original site. This physiological center is essential for differentiation and, where analyzed, functions as a dynamic center whence proceed waves of contraction in the yolk system which control differentiation and regulation. In the bee it is a "concentration center of potencies." The embryonic differentiation center is also concerned in the development of adult structures in *Drosophila*. (Section VII-B.)



The entire egg must be regarded as a system in which not only the embryonic part and its included factors but also the extra-embryonic parts, especially the yolk system, are instrumental in determination, differentiation and regulation. Determination is carried out by a harmonious alternating series of interacting dynamic processes (flowing and contraction) and material reactions, the former involving the egg system as a whole and enabling the reactions of more or less definite centers. Hence developmental processes are not primarily the result of the functioning of 'centers' but rather of the relations existing in the egg as a whole. (Section VII-C.)

On this basis a comparison can be drawn between insect and amphibian eggs, but at present the superficial resemblances scarcely allow direct analogy of the vertebrate organizer with either the insect activation center or differentiation center or both. (Section VII-D.)

7. Blastokinesis, at least in the grasshopper, is accomplished by vigorous movements of the embryo itself. (Section VIII.)

8. Maps have been made of the general embryonic anlagenplan of the damselfly (by defect experiments which show potencies rather than true promorphology) and of the potencies of the various levels of the Honey Bee egg (by constriction experiments). In the determinate eggs of Diptera presumptive anlagen arise at the points where the corresponding organs first become visible. (Section IX.)

9. There are only incidental experimental data on organ-formation, the mosaic stage of differentiation having still to be analyzed in detail. Notes are given on the endoderm, germ cells, imaginal discs, organ duplications and order of embryonic determination. In certain insects in which some of the cleavage nuclei become segregated at an early stage at the posterior pole of the egg ('pole cells') it has been conclusively proved that these cells give rise to the definitive germ cells. (Section X.)

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## THE GENOTYPES OF THE NORTH AMERICAN HADENINÆ (LEPIDOPTERA, NOCTUIDÆ)

BY HARRISON M. TIETZ, PH.D.

STATE COLLEGE, PA.

In the December 1933 issue of the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY (pages 441-456), the writer published a list of the genotypes of the North American Hadeninæ. This list also stated when and by whom these types were designated. That article with some additions forms the basis for the present paper.

Probably no group of insects needs a more careful revision than the Noctuidæ (Phalenidæ). Such a task is not easy because so many species are involved. Many have tried to group these species into genera but few workers agree upon what constitutes a genus. This lack of harmony has led to confusion. Many specialists will accept a genus even though they may not be able to define it. Most of the recently erected genera have been well described and defined but the older ones need to be redescribed and their boundaries more clearly set. To properly define a genus, one should consider all morphological characters even if they seem to have no generic value. This may make the generic description rather lengthy but the information contained in such a description will be of great value to those who wish to make a critical comparison of related genera. The salient characters could be listed first—say in italics—so that it would be unnecessary to read through the entire description.

Where should one begin in forming generic concepts? The writer believes that the genotypes offer a good starting point. Having worked out their structure, we now have morphological “yardsticks” with which we can measure other species and see where they fit. It is true that no one species can show the range of variation within the genus but we may start with one species and group others about it. Having done this, we may turn back and elaborate upon our original generic concept. It is the aim of this article to describe these basic species in the North American

Hadeninae so that others may supplement it with a morphological study of species other than genotypes.

#### SCOPE OF THE ARTICLE

This article includes the following—First—most of the Hadenine genera found in North America; Second—all genera considered synonymic with our genera; Third—a few purely exotic genera which have found their way in our lists from time to time. Some of the latter group have been considered synonymic with our genera and in a few cases our genera have been considered synonymic with them.

In the first group we have the following—Acerra Grt., Admetovis Grt., Anarta Ochs., Barathra Hub., Borolia Moore, Buchholzia Barnes and Benj. (Eubuchholzia B. and B.), Cardepiia Hampson, Cea Grt., Ceramica Gn., Chabuata Walk., Copimamestra Grt., Craterestra Hamp., Discestra Hamp., Engelhardtia Barnes, Epia Hub., Eriopyga Gn., Eupsephopaectes Grt., Faronta Smith, Hadena Schrank, Heliophila Hub., Himella Grt., Hyperepia Barnes and Lind., Lasiestra Hamp., Lasionycta Auriv., Leucania Ochs., Lophoceramia Dyar, Mamestra Ochs., Miodera Smith, Morrisonia Grt., Neleucania Smith, Nephelodes Gn., Ommatostola Grt., Parameana Barnes and Benj., Perigonica Smith, Perigrapha Lederer, Pseudorthodes Morrison, Scotogramma Smith, Stretchia Hy. Edw., Trichoclea Grt., Trichocosmia Grt., Tricholita Grt., Trichopolia Grt., Ulolonche Smith, Ursogastra Smith, Xanthopastes Hub., Xylomania Hamp., Zosteropoda Grt.

In the second group: Synonym for Eriopyga-Hypotrix Gn., Synonyms for Hadena-Aethria Hub., Aplecta Gn., Astrapetis Hub., Crocigrapha Grt., Dargida Walk., Dianthoecia Bois., Diataraxia Hub., Neuria Gn. Incorrectly considered synonymic with Mamestra Aletia Hub., Alysia Gn., Charaeas Steph., Haderonia Staud., Hyphilare Hub., Hyssia Gn., Melanchra Hub., Meterana Butl., Synonymic with Nephelodes Monosca Walk., Monostola Alpher., Synonymic with Xanthopastes Philochrysa Grt. The exact status of all of these genera will be considered in the article.

In the third group Neuronina Hub. (Epineuronina Staud.), Eury-

psyche Butl., Ichneutica Mey., Magusa Walk., Meliana Curtis, Naesia Walk., Pastona Walk., Sideridis Hub., Xylomyges Gn.

#### DESCRIPTION AND DESIGNATION OF MORPHOLOGICAL CHARACTERISTICS

In this section each morphological character will be described and given a type number, *e. g.* frons type 1, male antennæ type 2, etc. Throughout the article these type numbers will be used in describing the genotypes—not because the writer prefers this method—but to save space and to reduce the cost of publication.

#### The Head

##### Vestiture.

Type 1—hair.

Type 2—hair and scales.

Type 3—scales.

Type 4—deeply cleft scales.

##### Compound Eyes.

Type 1—apparently naked.

Type 2—hair restricted to the posterior portion of the eye.

Type 3—uniformly clothed with hair.

##### Frons.

Type 1—rather uniformly rounded.

Type 2—tends to project forward and upward.

Type 3—tends to project forward and downward.

Type 4—protrudes forward, not rounded, front almost vertical.

Type 5—protrudes slightly forward and downward, with indications of a slight “T” shaped protuberance.

Type 6—rounded and full, front slightly excavated.

Type 7—uniformly rounded, ventral margin with a knob-like prominence.

Type 8—with an inverted heart shaped protuberance which is smooth on its frontal surface.

Type 9—with an inverted heart shaped protuberance that is roughened on its frontal surface.

Type 10—with a truncated conical corneous process.

Type 11—with a semi-lunate corneous prominence raised at its edges.

Type 12—extends forward and upward in the form of an inverted wedge which bears near its apex a smaller wedge-shaped prominence. Ventral margin with an upturned corneous ridge.

Type 13—protrudes forward and upward with the frontal surface convex.

#### **Antennæ of the male.**

Type 1—filiform, scaled above, ventral surface clothed with fine cilia to long hair, setæ may or may not be present. Antennæ round or oval in cross section, sometimes flattened on the ventral surface.

Type 2—filiform and similar to type 1 except that the antennæ are wedge-shaped in cross section.

Type 3—crenulated, scaled above, clothed with very long cilia beneath. Each segment bears a pair of very long lateral setæ.

Type 4—crenulated, scaled above, ventral surface of the crenulations bearing short cilia. At the tip of each crenulation there is a pencil of very long hair.

Type 5—crenulated and flattened, scaled above, ventral surface of the crenulations along their distal margins bear long hair. At the extremity of each crenulation there is a stiff seta which is more or less hidden by the hairy vestiture.

Type 6—crenulated, scaled above, bearing fine cilia beneath. At the tips of the crenulations are pencils of long hairs no lateral setæ present.

Type 7—crenulated, dorsal surface scaled, ventral surface covered with short hair. Each crenulation bears at its tip a tuft of long hair and a setum.

Type 8—serrate, clothed above with scales and ventrally with a combination of fine cilia long hairs. The hairs are restricted to the distal portions of the segments.

Type 9—serrate, the serrations formed by wedged-shaped prominences on the ventral surface of the shaft. These prominences are clothed with long hair and a pair of lateral setæ. Dorsally the antenna is scaled.

Type 10—serrate, almost bipectinate, dorsal surface scaled, ventral surface covered with hair with longer bristles of hair on the tips of the serrations and on their mid-ventral surfaces. Serrations not of the same size on both sides of the antenna.



Type 11—bipectinate but not flattened, pectinations not of the same size on both sides of the shaft, even the longer ones quite short. At the end of each branch there is a rather prominent setum. The antenna is scaled above, finely ciliated beneath with the exception of the pectinations which are clothed beneath with long hair.

Type 12—flattened and bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface scaled, ventral surface clothed with long hair. At the tips of each pectination there is a very prominent seta. Ventral surface of the shaft serrated.

Type 13—bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface scaled, ventral surface clothed with long hair. Each pectination terminated with a prominent seta. Ventral surface of the shaft crenulated.

Type 14—bipectinate and serrate, pectinations longer on one side than the other. Antenna scaled above, ventral surface of the shaft and pectinations clothed with long hair. At the end of each pectination there is a rather stout seta.

Type 15—bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface of the antenna scaled, ventral surface of the shaft and pectinations clothed with long hair.

Type 16—bipectinate, pectinations not of the same size on both sides of the shaft. Segments very distinct on their dorsal surface which is clothed with scales. Ventral surface of the shaft and the pectinations clothed with very long hair. Hair at the tips of the pectinations a trifle longer.

Type 17—bipectinate, pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with moderately long hair.

Type 18—bipectinate, the pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and pectinations clothed with long hair. At the tips of each pectination there are three prominent setæ.

Type 19—bipectinate, pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and of the pectinations clothed with short hair. At the tips of each pectination there are two or three short setae.

Type 20—bipectinate, pectinations equal on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. No setæ at the tips of the pectinations.

Type 21—bipectinate, pectinations almost the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip a prominent seta.

Type 22—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip a prominent seta.

Type 23—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip two or three prominent setae. Shaft serrate ventrally.

Type 24—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled dorsally, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip several prominent setæ.

#### **Antennæ of female.**

Type 1—filiform, scaled above, vestiture of the under side varies from long hair to fine cilia. Setæ may or may not be present. Antennæ oval or round in cross section.

Type 2—filiform, scaled above, vestiture beneath varies from long hair to fine cilia. Setæ may or may not be present. Antennæ wedge shaped in cross section.

Type 3—serrate when viewed from the side, ventrally each segment is heart-shaped, the upper lobes bearing several prominent setæ. Dorsally scaled, ventral surface covered with fine cilia.

Type 4—crenulated, scaled above, finely ciliated beneath. Each segment bears at least one pair of long setæ near its distal extremity.

Type 5—serrate, dorsally scaled, ventrally clothed with moderately long hair. Each segment bears a pair of prominent setæ.

Type 6—serrate and flattened. Dorsally scaled, ventral surface covered with long hair. Each segment bears a pair of lateral setæ.

Type 7—serrate, the serrations not of the same size on both sides of the shaft. Dorsal surface clothed with scales, ventrally covered with fine hair. Each segment bears a pair of very long lateral setæ.

Type 8—bipectinate, pectinations short and of the same size on both sides of the shaft. Dorsally scaled, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip a prominent seta.

Type 9—bipectinate, pectinations long and of the same size on both sides of the shaft. Dorsally scaled, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip a prominent seta.

#### **Vestiture of the palpi.**

Type 1—all segments compactly scaled.

Type 2—all segments scaled.

Type 3—proximal segment bearing a mixture of hair and scales, all other segments scaled.

Type 4—proximal and middle segments bears a mixture of hair and scales, distal scaled.

Type 5—all segments bearing a mixture of hair and scales.

#### **Ratio of the palpal segments.**

Type	Distal	Middle
1	1.0	.75-1.9
2	1.0	2.00-2.90
3	1.0	3.00-3.90

#### **Proboscis.**

Type 1—fully developed.

Type 2—poorly developed or weak.

#### **The Thorax**

##### **Vestiture of the thorax.**

Type 1—hair.

Type 2—hair and scales.

Type 3—scales.

**Crests.**

Type 1—none.

Type 2—a prothoracic crest present; others, if present, indistinct.

Type 3—indistinct pro- and meta-thoracic crests.

Type 4—indications of meta-thoracic crest.

Type 5—a divided pro- and a distinct meta-thoracic crest.

Type 6—a divided pro-, a meso-, and a meta-thoracic crest.

**Costal margin of the primaries.**

Type 1—straight.

Type 2—straight but lobed at the base.

Type 3—slightly convex.

Type 4—concave.

**Apex of the primaries.**

Type 1—truncated.

Type 2—rounded.

Type 3—drawn downward, sometimes to a point.

Type 4—pointed.

**Outer margin of the primaries.**

Type 1—straight to very obliquely incurved.

Type 2—slightly convex.

Type 3—rounded outwardly at the tips of veins  $M_2$  and  $M_3$ , very oblique to anal margin.

Type 4—rounded outwardly at the tips of veins  $M_3$  and  $Cu_1$ , very oblique to anal margin.

Type 5—excavated to the middle where it forms a distinct angulation.

**Sc and R of the secondaries.**

Type 1—Sc and R confluent at their bases.

Type 2—Sc and R touching near the base of the wing, then diverging.

**Vestiture of the fore-leg.**

Type 1—femur of the fore-leg fringed with coarse hair beneath, remainder of the leg scaled.

Type 2—leg scaled throughout, not fringed with hair.



**Structure of the fore-leg.**

Type 1—typical in structure, *i.e.*, with only the usual spines present. (See Fig. 268.)

Type 2—fore-tibia with a curved claw on the outer side.

Type 3—a large curved spine near the distal end of the first tarsal segment, all spines on the first and second tarsal segment overdeveloped.

Type 4—one or two curved claws on the anterior face of the fore-tibia, also a large curved spine at the distal extremity of the first tarsal segment.

Type 5—the distal portion of the tibia bearing several large spurs on the anterior and posterior faces.

Type 6—tibiæ with several short spines.

Type 7—with at least three very large spines on the outer side of the first tarsal segment, on the succeeding two segments the spines are overdeveloped on the outer side.

**Vestiture of the middle leg.**

Type 1—scaled, ventral edge of the femur and dorsal margin of the tibiæ fringed with coarse hair and long scales.

Type 2—scaled throughout, not fringed with hair.

**Structure of the middle leg.**

Type 1—typical in structure, *i.e.*, with only the usual spines on the tarsi and the two spurs on the tibia. (See Fig. 269.)

Type 2—tibiæ with several short spines rather evenly distributed.

**Vestiture of the hind leg.**

Type 1—as type 1 of the middle leg.

Type 2—as type 2 of the middle leg.

**Structure of the hind leg.**

Type 1—typical in structure, *i.e.*, with only the usual spines on the tarsi and four spines on the tibia. (See Fig. 270.)

Type 2—as type 2 of the middle leg.

**The Abdomen****Vestiture of the abdomen.**

Type 1—hair dorsally and ventrally.

Type 2—dorsally hair, ventrally mixed hair and scales.

Type 3—dorsally hair, ventrally scaled.

Type 4—dorsally mixture of hair and scales, ventrally mostly scales.

Type 5—dorsally mixture of hair and scales, ventrally hair.

Type 6—dorsally and ventrally mixture of hair and scales.

Type 7—dorsally and ventrally scaled.

#### Dorsal abdominal crests.

Type 1—none.

Type 2—poorly defined.

Type 3—one on the first segment.

Type 4—a crest on the first and second segments.

Type 5—a crest on the first, indications of crests on the second and third.

Type 6—crests on the first, second, and third segments.

Type 7—a row of mid-dorsal crests.

#### Lateral abdominal crests.

Type 1—none present.

Type 2—crests indistinct.

Type 3—present and distinct.

#### KEY TO THE GENOTYPES

In making this key the writer has avoided, as far as possible, the use of such sexual characters as the structure of the male or female antennæ. To do this it was sometimes necessary to make distinctions on the basis of the vestiture of the head or thorax or even the presence or absence of thoracic and abdominal crests. The use of such characters in the key is merely for convenience and they are not to be considered of primary importance in generic classification.

It is hoped that this key can be used to classify the many North American species of Hadeninæ other than genotypes.

1. Eyes apparently naked, *i.e.*, clothed with very fine cilia .....2  
     Eyes clothed with short hair that is confined to the posterior portion.....4  
     Eyes clothed with hair that is uniformly distributed .....6
2. Frons protrudes forward and upward with the frontal surface convex.  
     *Parameana*  
     Frons rather uniformly rounded although sometimes rather prominent...3
3. Legs rather compactly scaled, antenna of the male serrate.....*Ommatostola*  
     Legs fringed with long hair and scales, antenna of male filiform.  
     *Buchholzia*
4. Vestiture of the thorax a mixture of hair and scales .....5  
     Vestiture of the thorax scales .....*Trichopolia*

5. Apex of the primaries truncated, antennæ of the male bipectinate, of the female filiform ..... *Lophoceramica*  
 Apex of the primaries rounded, antenna in both sexes bipectinate. .... *Tricholita*  
 Apex of the primaries drawn downward, antenna of the male filiform. .... *Ursogastra*
6. Frons uniformly rounded, ventral margin with knob-like prominence. .... *Xanthopastes*  
 Frons uniformly rounded, ventral margin without a knob ..... 7  
 Frons not uniformly rounded ..... 24
7. Proboscis fully developed ..... 8  
 Proboscis poorly developed ..... 22
8. Costal margin of the primaries straight ..... 9  
 Costal margin of the primaries straight but lobed at the base. .... *Utolonche*  
 Costal margin of the primaries slightly convex ..... 16  
 Costal margin of the primaries slightly concave ..... 20
9. Outer margin of the primaries straight to obliquely incurved ..... 10  
 Outer margin of primaries rounded outwardly at the tips of veins  $M_2$  and  $M_3$  very oblique to anal margin ..... *Pastona*  
 Outer margin of the primaries rounded outwardly at the tips of  $M_3$  and  $Cu_1$  very oblique to the anal margin ..... *Hypotrix*  
 Outer margin of the primaries excavated to the middle where it forms a distinct angulation ..... *Perigonica*
10. Fore leg with only the usual spines ..... 11  
 Fore leg with at least three very large spines on the outer surface of the first tarsal segment, on the next two segments the spines on the outer side are overdeveloped ..... *Admetovis*
11. Vestiture of the head hair only ..... 12  
 Vestiture of the head hair and scales or scales only ..... 15
12. Vestiture of the thorax hair only ..... 13  
 Vestiture of the thorax hair and scales or scales only ..... 14
13. Apex of the primaries drawn downward, vestiture of the abdomen hair and scales dorsally and ventrally ..... *Acerra*  
 Apex of the primaries truncated, dorsal surface of the abdomen covered with hair, ventral surface with hair and scales ..... *Alysia*
14. No dorsal abdominal or thoracic crests ..... *Heliophila*  
 Thoracic and dorsal abdominal crests present ..... *Chabuata*
15. (a) Antenna of the male filiform, oval or round in cross section. .... *Melanchra* group  
 (b) Antenna of the male filiform, wedge-shaped in cross section. .... *Pseudorthodes* and *Hadena* group  
 (c) Antenna of the male crenulated, ventral surface bears short cilia, pencils of long hairs at the tips of the crenulations ..... *Xylomyges*  
 (d) Antenna of the male crenulated and flattened, scaled above, ventral surface of the crenulations along their distal margins bearing

- long hair, at the extremity of each crenulation there is a stiff seta ..... *Morrisonia*
- (e) Antenna of the male bipectinate, not flattened, pectinations not of equal size on opposite sides of the shaft and all quite short, ventral surface ciliated and at the end of each pectination there is a long setum ..... *Nephelodes*
- (f) Antenna of the male bipectinate, not flattened, pectinations not of equal size on opposite sides of the shaft, dorsal surface scaled, ventral surface clothed with long hair. Each pectination bears at its tip a prominent setum. Ventral surface of the shaft crenulated ..... *Stretchia*
- (g) Antenna of the male bipectinate and flattened, pectinations not of equal size on opposite sides of the shaft, ventral surface clothed with long hair. At the tip of each pectination there is a stout setum. Ventral surface of the shaft serrate ..... *Hyperepia*
- (h) Antenna of the male bipectinate and serrate but not flattened. The pectinations longer on one side of the shaft than the other. Antenna scaled above, ventral surface clothed with long hair. There is a stout setum at the tip of each pectination ..... *Haderonia*
16. Vestiture of the legs compact scales ..... *Meliana*  
Vestiture of the legs hair and scales ..... 17
17. Apex of the primaries drawn downward ..... *Eriopyga*  
Apex of the primaries truncated ..... 18
18. Vestiture of the palpi scales only ..... *Borolia*  
Proximal and middle segments of the palpi bearing hair and scales, distal segment scaled ..... 19
19. Antenna of the male filiform, middle segment of palpi more than twice the length of the distal ..... *Naesia*  
Antenna of the male crenulated, middle segment of the palpi not more than twice the length of the distal ..... *Himella*
20. Apex of the primaries truncated ..... *Anarta*  
Apex of the primaries pointed ..... 21
21. Palpi with the proximal segments clothed with hair and scales. *Zosteropoda*  
Palpi with all segments compactly scaled ..... *Neleucania*
22. Outer margin of the primaries slightly convex ..... *Charaeas*  
Outer margin of the primaries straight or obliquely incurved ..... 23
23. Vestiture of the head and thorax hair ..... *Monostola*  
Vestiture of the head and thorax hair and scales or scales only. *Epineuronia*
24. Frons projects forward and upward ..... 25  
Frons projects forward and downward ..... 32  
Frons protrudes forward and downward with indications of a slight "T" shaped protuberance ..... *Epia*  
Frons rounded out, front slightly excavated ..... *Ichneutica*



Frons with an inverted heart shaped protuberance which is smooth on its frontal surface .....	<i>Trichoclea</i>
Frons with an inverted heart shaped protuberance which is roughened on its frontal surface .....	<i>Miodera</i>
Frons extends forward and upward in the form of an inverted wedge which bears near its apex a prominence .....	<i>Cea</i>
Frons with a truncated conical prominence .....	<i>Craterestra</i>
Frons with a semi-lunate prominence with raised edges .....	<i>Discestra</i>
25. Proboscis fully developed .....	26
Proboscis poorly developed .....	31
26. Costal margin of the primaries straight .....	27
Costal margin of the primaries straight but lobed at the base.	
	<i>Lasiestra</i>
Costal margin of the primaries slightly convex .....	<i>Eurypsycha</i>
27. Fore leg with only the usual spines .....	28
Fore leg with a curved claw on the outer side.	
	<i>Mamestra</i> and <i>Copimamestra</i>
28. Legs compactly scaled .....	<i>Trichocosmia</i>
Legs fringed with hair and scales .....	29
29. Antenna of the male bipectinate, of the female serrate .....	<i>Xylomania</i>
Antennæ in both sexes filiform .....	30
30. No distinct thoracic crest .....	<i>Cerdepia</i>
Distinct thoracic crest .....	<i>Barathra</i> and <i>Scotogramma</i>
31. Apex of primaries truncated, thoracic crests present .....	<i>Perigrapha</i>
Apex of primaries drawn down, no thoracic crests .....	<i>Engelhardtia</i>
32. Outer margin of the primaries straight or very obliquely incurved, vestiture of the thorax hair .....	<i>Sideridis</i>
Outer margin of the primaries slightly convex, vestiture of the thorax scales .....	<i>Neuria</i>

### The Hadeninæ

The Noctuidæ can be divided into two groups on the basis of the development of vein 5 ( $M_2$ ) of the hind wing. By far the greater number belong to the group in which this vein is well developed but in four subfamilies *i.e.*, Hadeninæ, Cucullianæ, Agrotinæ, and Acronyctinæ, vein 5 is obsolescent from the middle of the discocellulars. It can be seen from this that the Hadeninæ are closely related to three other subfamilies. Hampson gives the following key for the separation of the four subfamilies.

“A <sup>1</sup> Mid and hind tibiæ or hind tibiæ only spined.....	Agrotinæ
B <sup>1</sup> Mid or hind tibiæ not spined.	
A <sup>2</sup> Eyes hairy .....	Hadeninæ
B <sup>2</sup> Eyes not hairy.	
A <sup>3</sup> Eyes overhung with cilia .....	Cucullianæ
BB <sup>3</sup> Eyes not overhung with cilia .....	Acronyctinæ”

A more complete description of the Hadeninæ, taken from Hampson, is as follows: "Proboscis usually well developed, sometimes aborted; palpi usually short, upturned or porrect; frons often with rounded prominence with corneous plate below it, or with corneous processes of various forms; eyes hairy, sometimes overhung by long cilia; antennæ usually ciliated, often pectinated or serrate. Thorax clothed with hair and scales when there are usually crests on the pro- and meta thorax, or a ridge like dorsal crest, or clothed with hair only; tibiæ without spines, the fore tibia rarely with terminal spine, the proximal joints of the fore tarsi sometimes with curved claw-like spines, abdomen usually with series of dorsal crests or one crest at the base. Wings usually broad, the termen rounded or crenulate, rarely slightly angulated at the middle; fore wing with vein 1a weak, not anastomosing with 1b; 1c absent; 2 from middle of cell; 3 and 5 from near lower angle; 6 from upper angle; 9 from 10 anastomosing with 8 to form the areole; in *Erana* with 7, 8, 9, stalked; 10 from cell. Hind wings with veins 1a and 1b present, 1c absent; 3 and 4 from lower angle of cell; 5 obsolescent from or from just below the middle of the discocellulars; 6, 7 from upper angle or shortly stalked; 8 arising free then bent down touching the cell then again diverging. In several genera the males often have secondary sexual tufts of hair or fans of scales on the thorax, legs or abdomen and in the genus *Eriopyga* patches of androconia on the wings of very diverse forms. In *Cirphis* the underside is sometimes clothed with silvery metallic scales."

Of the characteristics mentioned above, many of which are not peculiar to the Hadeninæ, the vestiture of the eyes and the spinosity of the tibiæ deserve further consideration.

In the typical Hadeninæ, the eyes are evenly clothed with hair which may be long or short. However, this characteristic is not constant for the entire subfamily for in three genera the eyes appeared to be naked (Dr. Barnes claims that hair is present but very fine and difficult to see) and in four other genera the hair is present but confined to the posterior portion of the eye.

As a rule the tibiæ of the Hadeninæ are not provided with spines the spinose condition being found chiefly in the Agrotinæ. However one genus whose hairy eyes place it in the Hadeninæ, shows developed spines or claws on the tibiæ.

It would seem from what has been said concerning the vestiture of the eyes and the spinosity of the tibiæ, that there are several Hadenine genera which stand between the true Hadeninæ and its allied subfamilies. This fact has some bearing upon the arrangement of the genera in this article. Since the members of the related subfamilies have naked eyes, the writer assumes that the stock from which the Hadeninæ arose also had naked eyes. This idea seems to be supported by the fact that in three genera the cilia upon the eyes are so fine that the eyes appear to be naked. In four other genera the eyes are only partly clothed with hair.

The spinosity of the fore tibia is also an unusual character among the Hadeninæ and may indicate relationship to the Agrotinæ. If the Agrotinæ and Hadeninæ are closely related, say through a common ancestor, then the one Hadenine genus in which the fore tibia is spined should be considered first. This is the reason for placing *Mamestra* (*Copimamestra*) first. This genus has, however, taken on the Hadenine character of hairy eyes. Another line of development is indicated by *Buchholzia*, *Ommatostola*, and *Parameana* in which the spinose condition of the fore tibia is lost but the eyes are almost naked and the writer believes that in some specimens they are naked. These three genera must also be considered as standing close to the base of the Hadenine stem and for this reason they form the second group to be considered. The *Buchholzia* group seem to lead into forms in which the eyes are partly clothed with hair so this group is followed by *Ursogastra*, *Lophoceramica*, *Tricholita*, and *Trichopolia* in which the hair is confined to the posterior part of the eye.

Next comes the bulk of the genera that are typical Hadenines having uniformly hairy eyes and no tibial spines or claws. There are many ways in which these could be divided but the writer has chosen to arrange them on the basis of wing form—those in which the outer margin is more or less even and those in which the outer margin is produced in the form of a lobe or angulated. The former section, normal wing form, can be further divided into two groups: (1) those with enlarged spines on the first tarsal segment, (2) those in which all tarsal spines are normal in their development.

The genera are accordingly grouped in the following sequence.

## Eyes uniformly hairy

Group 1—Fore tibia armed with a distinct claw—*Mamestra* (*Copimamestra*).

## Tibiæ without claws

Group 2—Eyes naked or apparently so—*Eubuehholzia*, *Parameana*, and *Ommatostola*.

Group 3—Eyes partly clothed with hair—*Ursogastra*, *Lophoceramica*, *Trichopolia*, and *Tricholita*.

## Eyes uniformly hairy

Group 4—Margin of the fore wing produced—*Perigonica*, *Pastona*, and *Hypotrix*.

Group 5—Margin not produced, fore tarsi with enlarged spines—*Epia* and *Admetovis*.

Group 6—Margin not produced, tarsi without enlarged spines. This group can be divided as follows:

## Section A—Frons uniformly rounded

Subsection I—Antennæ simple in both sexes (filiform).

(a) Antennæ of the male oval in cross section—*Anarta*, *Chabuata*, *Ulolonche*, *Aletia*, *Zosteropoda*, and *Neleucania*, *Melanchra*.

(b) Antennæ of the male wedge-shaped in cross section—*Hadena*, *Eriopyga*, *Pseudorthodes*, *Naesia*, *Borolia*?, *Meliana*, and *Heliophila*.

Subsection II—Antennæ of the male never filiform—*Morrisonia*, *Xylomyges*, *Himella*, *Alysia*, *Hyperepia*, *Nephelodes*, *Monostola*, *Characas*, *Haderonia*, *Epineuronia*, *Açerra*, *Stretchia*.

## Section B—Frons not uniformly rounded

Subsection Ia—Antennæ of the male never filiform—*Perigrapha*, *Xylomania*, *Engelhardtia*, *Lasiestra*, and *Eurypsyche*.

Subsection Ib—Antennæ of the male filiform—*Cardepi*a, *Trichocosmia*, *Barathra*, *Scotogramma*, *Dianthoea*, *Sideridis* and *Neuria*.

Subsection IIa—Frons ornamented or excavated, antennæ of the males simple—*Xanthopastes*, *Craterestra*, *Discestra*, *Cea*, and *Trichoclea*.



Subsection IIb—Frons ornamented but the antennæ in both sexes not simple—Ichneutica and Miodera.

### Group I

This group includes *Mamestra* Ochs. and its equivalent *Copimamestra* Grote. At first the writer considered *Noctua persicariæ* Linn. as the genotype of *Mamestra* on the basis of Westwood's designation in 1839 (Synopsis of the Genera British Insects, page 95.) but Dr. McDunnough of the Canadian Bureau of Entomology pointed out to the writer that the type was designated 1829 by Duponchel as *Noctua brassicæ* Linn. (Godart's and Duponchel's *Historie Naturelle des Lepidopteres*, VII, Part II, pp. 71-72.) In 1883, Grote erected the genus *Copimamestra* in which he included *brassicæ* Linn and a new species *occidentæ* Grt. He mentions the curved claw on the fore tibia as the chief characteristic and goes on to say, "The types are the European *C. brassicæ* and the following new species." Hampson in 1905 designated *brassicæ* as the type of *Copimamestra* which is in harmony with Grote's statement so it may be considered as genotype of *Copimamestra*. This makes *Copimamestra* the equivalent of *Mamestra*, both having the same species for genotype.

*Noctua brassicæ* Linn has the characteristic hairy eyes of a Hadenine but also possesses the unusual claw-like structure on the fore tibia. This is an outstanding character which should serve to identify the genus.

### Synopsis of Morphological Characters

#### Head:

Vestiture 2, Compound eyes 3, Frons 2, Antennæ male 1 hair beneath, of the female 1 ciliated beneath, Vestiture of the palpi 4, Ratio of the palpal segments 2, proboscis 1.

#### Thorax:

Vestiture 2, Crests 5, Primaries costa 1, apex 1, outer margin 1 (incurved), Secondaries 1, Vestiture of the fore leg 1, structure 2, Vestiture of middle and hind legs 1, structure of middle and hind legs 1.

#### Abdomen:

Vestiture 6, Dorsal crests in male 7 (1st to 5th), in the female 3, Lateral crests in the male 2, in the female 1.

## Group II

In this group may be placed three genera, Eubuchholzia, Ommatostola, and Parameana. The type of Eubuchholzia is *Arsilonche colorada* Smith, of Ommatostola is *O. lintneri* Grt., and of Parameana, *Hadena laetabilis* Smith. In these three species the fore tibiae are without the claw found in Group I but the eyes are either naked or apparently so. The hairs between the facets are so small and so few in number that it is very easy to overlook them.

These genotypes can be separated in the following way:

1. Frons rather uniformly rounded ..... 2  
Frons projects forward and upward, frontal surface convex.  
Parameana B. & Benj.
2. Antennae of the male filiform ..... Eubuchholzia B. & Benj.  
Antennae of the male serrate ..... Ommatostola Grt.

## Synopsis of Morphological Characters

	Para- meana	Eubuch- holzia	Ommato- stola
Head:			
Vestiture .....	3	2	3
Compound eyes .....	1	1	1
Frons .....	13	1	1
Antennae of male .....	×	2, hair and setae beneath	9
Antennae of the female .....	2, ciliated, no setae beneath	×	1, cilia and lat- eral and mid- ventral setae
Vestiture of palpi .....	4	4	2
Ratio of palpal segments...	2	2	2
Proboscis .....	1	1	1
Thorax:			
Vestiture .....	3	3	2
Crests .....	4	4	4
Costa of primaries .....	1	1	1
Outer margin of primaries	1, incurved	1, incurved	1, incurved
Apex of primaries .....	2	3	2
Sc. and R of secondaries....	2	1	1
Fore leg—vestiture .....	1	1	2
“ “ —structure .....	1	1	1
Middle leg—vestiture .....	1	1	2

“ “ —structure .....	1	1	1
Hind leg—vestiture .....	1	1	2
“ “ —structure .....	1	1	1
Abdomen :			
Vestiture .....	6	4	7
Dorsal crests .....	3	1	1
Lateral crests .....	1	2	3

## Group III

In this group we have four genera which are more typically Hadenine in character. The fore tibiæ are not spurred and the eyes are markedly hairy but the hair in these genera is confined to the posterior portion of the eye. This group consists of the following genera: *Ursogastra* Smith (type *lunata* Smith), *Lophoceramica* Dyar (type *artega* Barnes), *Tricholita* Grote (type *semiaptera* Morr.), and *Trichopolia* Grote (type *dentatella* Grote). By looking over the synopsis of morphological characters, one will see that all four genotypes have much in common and that the best way to separate them on the basis of the structure of the antennæ. This may be done in the following way:

1. Antenna of the male filiform ..... *Ursogastra* Smith  
Antenna of male not filiform ..... 2
2. Antenna of male bipectinate, pectinations the same size on both sides ..... 3  
Antenna of the male bipectinate and serrate, pectinations not of the same size on both sides of the shaft ..... *Trichopolia* Grote
3. Antenna of the female filiform ..... *Lophoceramica* Barnes  
Antenna of the female bipectinate ..... *Tricholita* Grote

## Group IV

Members of this group have the eyes uniformly hairy, fore tibia without a claw. The outstanding characteristic in this section is the shape of the fore wings for in each of these genotypes the outer margin of the upper wings is produced. Here we find the genus *Perigonica* Smith-type *angulata* Smith, *Pastona* Walk.-type *rudis* Walk, and *Hypotrix* Gn.-type *purpurigera* Gn. *Rudis* and *purpurigera* are Brazilian species and the genera of which they are the types may have no representatives in North America. The genus *Magusa* of Walker has for its type *albiguttalis* Walker. According to Hampson, *albiguttalis* is a synonym of *rudis* so

## Synopsis of Morphological Characters

	Ursogastra	Lophoceramica	Tricholita	Trichopolia
Head:				
Vestiture .....	3	2	2	2
Compound eyes .....	2	2	2	2
Frons .....	1	1	1	1
Antennæ, male .....	1, under side flat, hairy, lateral setæ	22	22	14
Antennæ, female .....		1, under side ciliated, lat- eral setæ	9	1, under side ciliated, lat- eral setæ
Vestiture of palpi .....	3	4	4	4
Ratio of palpal segments .....		2	2	1
Proboscis .....	1	1	1	1
Thorax:				
Vestiture .....	2	2	2	3
Crests .....	4	5	5	5
Costa of primaries .....	1	1	1	1
Apex of primaries .....	3	1	2	1
Outer margin of primaries .....	1, incurved	1, incurved	1, straight	1, straight
Sc and R of secondaries .....		2	2	1
Fore leg—vestiture .....	1	1	1	1
“ “ —structure .....	1	1	1	1
Middle leg vestiture .....	1	1	1	1
“ “ structure .....	1	1	1	1
Hind leg—vestiture .....	1	1	1	1
“ “ —structure .....	1	1	1	1
Abdomen:				
Vestiture .....	7	4	4	4
Dorsal crests .....	1	3	3	3
Lateral crests .....	3	3 male, 2 female	3	3 male, 1 female



*Magusa* sinks as a synonym of *Pastona*. The genera may be separated in the following way:

1. Antenna of the male serrate, almost bipectinate ..... *Perigonica* Smith  
    Antenna of the male filiform ..... 2
2. Apex of the fore wing rounded ..... *Pastona* Walk.  
    Apex of the fore wing drawn down to a point ..... *Hypotrix* Gn.

### Synopsis of Morphological Characters

	<i>Perigonica</i>	<i>Pastona</i>	<i>Hypotrix</i>
<b>Head:</b>			
Vestiture .....	1	3	1
Compound eyes .....	3	3	3
Frons .....	1	1	1
Antenna of the male .....	10	1, ciliated beneath lateral setæ	1, ciliated beneath lateral setæ
Antenna of the female .....	1, ciliated lateral setæ	1, fine cilia lateral setæ?	1, ciliated lateral setæ
Vestiture of the palpi .....	4	3	4
Ratio of the palpal segments .....	2	x	x
Proboscis .....	1	1	1
<b>Thorax:</b>			
Vestiture .....	2	3	3
Crests .....	5	5	5
Costa of primaries .....	1	1	1
Apex of primaries .....	4	2	3
Outer margin primaries .....	5	3	4
Sc. and R. of secondaries .....	x	x	x
Fore leg—vestiture .....	1	1	1
“ “ —structure .....	1	1	1
Middle leg—vestiture .....	1	1	1
“ “ —structure .....	1	1	1
Hind leg—vestiture .....	1	1	1
“ “ —structure .....	1	1	1
<b>Abdomen:</b>			
Vestiture .....	6	7, male, 4, female	6, male, 4, female
Dorsal crests .....	2	1	1
Lateral crests .....	3	1	1

## Group V

In this group we find two genera—*Epia* Hubner whose type is *echii* Bork, and *Admetovis* Grote with *oxymorus* Grote as its type. The first of these species is European and the genus may not be represented in this country. The other is native to the United States. Both species have the eyes uniformly hairy, fore tibiae without a claw, and wing form normal. The outstanding characteristic is the enlarged spines on the fore tarsi. If this character is not constant, then the species will fall in the next group. *Echii* has the frons protruding somewhat forward and downward with indications of "T" shaped protuberance. *Oxymorus* has the frons uniformly rounded. In *echii* the first tarsal segment of the fore tibia has a large curved spine near its distal end and all spines on the first and second tarsal segments are overdeveloped. In *oxymorus* the first tarsal segment of the fore tibia has at least three large spines on the outer side. On the succeeding two segments the spines are overdeveloped.

## Synopsis of Morphological Characters

	<i>echii</i>	<i>oxymorus</i>
Head:		
Vestiture .....	2	2
Compound eyes .....	3	3
Frons .....	5	1
Antenna of the male .....	1, long hair and lat- eral setæ	2, long hair and lat- eral setæ
Antenna of the female .....	1, ciliated with lat- eral setæ	1, ciliated with lat- eral setæ
Vestiture of the palpi .....	2	4
Ratio of the palpal segments.....	2	2
Proboscis .....	1	1
Thorax:		
Vestiture .....	2	3
Crests .....	5	5
Costa of primaries .....	1	1
Apex " " .....	2	1
Outer margin " .....	1, straight	1, incurved
Sc. and R. secondaries .....	2	2

Fore leg—vestiture .....	1	1
“ “ —structure .....	3	7
Middle leg—vestiture .....	1	1
“ “ —structure .....	1	1
Hind leg—vestiture .....	1	1
“ “ —structure .....	1	1
Abdomen :		
Vestiture .....	4	6, male ; 4, female
Dorsal crests .....	3	7
Lateral crests .....	3	2

Grote, in his original description of *Admetovis* mentions the pectinated condition of the antenna of the male. In specimens examined by the writer, the antenna was filiform. Smith, in Bull. 44, U. S. Nat. Mus. says, "The right of *Admetovis* to generic rank is decidedly questionable."

### Group VI

In this group we find the greatest number of genera. Their genotypes have the eyes uniformly hairy, tibiæ without claws or spines, margins of the fore wings not produced. The species can be easily separated on the bases of their frons. In section A the frons is uniformly rounded, in section B the frons is produced sometimes forming some type of ornamentation.

### Section A

Subsection I—Antennæ filiform in both sexes. Filiform antennæ are of two types. In one type the antenna is round or oval in cross section, in the other type ventral surface of each segment is raised to form a keel giving the antenna a wedge-shaped appearance when seen in cross section.

#### Subsection Ia—Antennæ of male oval

Costal margin of the fore wing straight .....	1
Costal margin of the fore wings lobed at the base.....	Ulolonche Smith
Costal margin of the fore wings concave .....	2

#### 1. All segments of the palpi bearing scales only.

Hyphilare Hub., Ceramica Gn., Chabuata Walk., Aletia Hub.

Some segments of the palpi bearing a mixture of hair and scales .....	1a
---	----

- |  |                            |
|--|----------------------------|
| 1a. Apex of the fore wing pointed .....                              | Meterana Butler            |
| Apex of the fore wing rounded .....                                  | Melanchra Hub., Hyssia Gn. |
| 2. All segments of the palpi bearing scales only .....               | Neleucania Smith           |
| Some segments of the palpi bearing a mixture of hair and scales..... | 2a                         |
| 2a. Apex of the fore wings truncated .....                           | Anarta Ochs.               |
| Apex of the fore wings pointed .....                                 | Zosteropoda Grote          |

### Hyphilare, Ceramica, Chabuata, and Aletia

*Hyphilare albipuncta* Schiff., *Ceramica picta* Harris, *Chabuata ampla* Walk., and *Aletia vitellina* Hub. are the four genotypes. *Albipuncta* and *vitellina* are European; *picta*, North American; and *ampla* is found in Brazil. It is easy to understand why *Ceramica picta* is included in this article but a few words of explanation are needed to justify the inclusion of the others. All four species plus *Meterana pictula*, *Melanchra persicariae*, and *Hyssia cavernosa* have been considered associated with the genus *Mamestra*. Many workers, including the writer, have accepted Westwood's designation of the genotype of *Mamestra* as *persicariae* Linn. (Westwood, "Synopsis of the Genera of British Insects," p. 95, 1839-1840.) Dr. McDunnough of Canada informed the writer that the type of *Mamestra* was designated in 1829 by Duponchel as *brassicæ* Linn. Since *brassicæ* has a curved claw on the fore tibia, the genus *Mamestra* does not fit with these genera and the next oldest genus to take its place is *Melanchra* of Hubner with *persicariae* as its type—a monotypical genus. *Melanchra* with its palpi clothed with both scales and hair differs from *Hyphilare*, *Ceramica*, *Chabuata*, and *Aletia*, in which all the palpal segments are covered only with scales. These four will be considered first. In looking over the synopsis of morphological characters below, it will be noted that all four genotypes have much in common with each other yet not one agrees entirely with any other one. *Hyphilare*, *Ceramica* and *Aletia* resemble each other in most respects and *Chabuata* stands off a bit by itself but not very distant so far as morphology is concerned. Our genus *Ceramica* may have to sink as a synonym of *Hyphilare* or *Aletia* if one would stress structure rather than coloration or wing patterns. See, however, a discussion of *Ceramica* under section pertaining to male genitalia.



	Hyphilare	Ceramica	Chabuata ♀	Aletia ♀
Head:				
Vestiture .....	2	2	1	2
Compound eyes .....	3	3	3	3
Frons .....	1	1	1	1
Antennæ of the male .....	1, long hair beneath	1, long hair lateral setæ	×	×
Antenna of the female .....	1, cilia	1, cilia	1, cilia lateral setæ	1, cilia lateral setæ
Vestiture of the palpi .....	1	2	2	2
Ratio of the palpal segments ..	3	3	×	2
Proboscis .....	1	1	1	1
Thorax:				
Vestiture .....	2	2	2	2
Crests .....	2	5	5	2
Costa of the primaries .....	1	1	1	1
Apex of the primaries .....	1	1	3	1
Outer margin of primaries .....	1, straight	1, incurved	1, straight	1, incurved
Sc. and R. of secondaries .....	2	2	×	2
Fore leg—vestiture .....	1	1	1	1
“ “ —structure .....	1	1	1	1
Middle leg—vestiture .....	1	1	1	1
“ “ —structure .....	1	1	1	1
Hind leg—vestiture .....	1	1	1	1
“ “ —structure .....	1	1	1	1
Abdomen:				
Vestiture .....	1 male, 4 female	6	4	1
Dorsal crests .....	2	2	3	2
Lateral crests .....	3 male, 1 female	3	1	1

Genus *Ulolonche* Smith

The type of this genus, *Ulolonche niveiguttata* Grote, exhibits many of the characters of the *Melanchra* group with the exception of the peculiar shape of the costa of the fore wings. It also appears to be related to the *Hyphilare* group. Owing to this dual relationship, the genus *Ulolonche* has been placed here between those two groups.

## Synopsis of Morphological Characters

## Head:

Vestiture 2, Compound eyes 3, Frons 1, Antennæ of the male 1 fine hair and lateral setæ beneath, in the female 1 ciliated and with lateral setæ beneath; Vestiture of the palpi 4, Ratio of the palpal segments 2, Proboscis 1.

## Thorax:

Vestiture 3, Crests 3, Costa of the primaries 2, apex of primaries 2, outer margin of primaries 1 incurved, Sc. and R. of the Secondaries 2, Vestiture and structure of all legs 1.

## Abdomen:

Vestiture 6, Dorsal crests 3, Lateral crests in male 3, in female 2.

*Melanchra*, *Meterana*, and *Hyssia*

The three genotypes—*Melanchra persicariæ* L., *Meterana pictula* White, and *Hyssia cavernosa* Evers—have at least one palpal segment clothed with a mixture of hair and scales and in this way at least they differ from the genotypes of the *Hyphilare* group. *Persicariæ* is European, *pictula* comes from New Zealand, and *cavernosa* is a Russian species. They are included here because the genera they represent have been erroneously associated with the genus *Mamestra*. In fact if we were to accept *persicariæ* as type of *Mamestra*, then *Melanchra* would sink as a synonym of that genus having the same species as its genotype. If we compare the three genotypes structurally, it will be noted that *Meterana* has five characters in common with *Melanchra* while *Hyssia* has only three. In making this comparison one should eliminate the six characters common to all three species. On

## Synopsis of Morphological Characters

	Melanchra	Meterana	Hyssia
Head:			
Vestiture .....	3	3	2
Compound eyes .....	3	3	3
Frons .....	1	1	1
Antenna of the male .....	1 ciliated	×	1 long hair
	lateral setae	1 ciliated	lateral setae
Antenna of the female .....	1 ciliated	lateral setae	1 ciliated
	lateral setae		lateral setae
Vestiture of the palpi .....	4	4	5
Ratio of the palpal segments .....	3	2	2
Proboscis .....	1	1	1
Thorax:			
Vestiture .....	3	2	2
Crests .....	5	2	5
Costa of the primaries .....	1	1	1
Apex of the primaries .....	2	3	2
Outer margin of the primaries .....	1 incurved	1 incurved	1 straight
Sc. and R. of the secondaries .....	2	2	2
All legs structure and vestiture .....	1	1	1
Abdomen:			
Vestiture .....	6	6	4
Dorsal crests .....	7	3	2
Lateral crests .....	2	3	2

## Synopsis of Morphological Characters

	Neleucania	Anarta	Zosteropoda
Head:			
Vestiture .....	2	1	1
Compound eyes .....	3	3	3
Frons .....	1	1	1
Antenna of the male .....	1 ciliated	1 hair and lateral setae	1 hair, lateral
Antennæ of the female .....	1 ciliated	1 ciliated	mid ventral setae
Vestiture of the palpi .....	lateral setae	lateral setae	1 cilia lateral
Ratio of palpal segments .....	1	4	mid ventral setae
Proboscis .....	×	2	3
Thorax:	1	1	1
Vestiture .....	2	2	1
Crests .....	6	3	1
Costa of primaries .....	4	4	4
Apex of primaries .....	3	1	3
Outer margin of primaries .....	1 incurved	1 incurved	1 incurved
Sc. and R. of the secondaries .....	×	2	1
Vestiture and structure of all legs .....	1	1	1
Abdomen:			
Vestiture .....	4	6	4
Dorsal crests .....	3	5	1
Lateral crests .....	1	2	1



the same basis *Meterana* and *Hyssia* have two characters in common. All this would indicate a close relationship among the three genera so far as their genotypes are concerned.

#### Neleucania, Anarta and Zosteropoda

The genotypes of these three genera are *Neleucania niveicosta* Smith, *Anarta myrtilli* Linn., and *Zosteropoda hirtipes* Grote. In these three species the costa of the primaries is concave, an unusual character in this subfamily. *Myrtilli* is the only European species the other two being native to the United States. All three genera are represented in this country however. *Neleucania* can be readily separated from the other two by the vestiture of the palpi. In this genus the palpal segments are clothed with scales only, in the other two at least one segment is covered with a mixture of scales and hair.

#### Subsection Ib Antenna of Male Wedge-shaped

In this substance the writer has placed fourteen genera one of which may have to be removed upon further study—genus *Borolia* Moore. All of the genotypes have much in common morphologically with the *Melanchra* group but there we find that the antennæ of the males, while filiform in structure, are more or less oval in cross-section while in this subsection—the *Hadena* like moths—the filiform antenna of the males is wedge shaped in cross section. Whether this is sufficient ground for separating the *Melanchra* and *Hadena* groups must be left to the reader. Probably it is best to consider this as an artificial grouping for convenience. The genotypes included in this subsection are as follows:

*Hadena* Schrank—type *cucubali* Schiff.

*Aethria* Hubner—type *serena* Schiff.

*Astrapetis* Hubner—type *dentina* Schiff.

*Dargida* Walk—type *grammivora* Walk.

*Diataraxia* Hub.—type *splendens* Hub.

*Eupsephopaectes* Gr.—type *procinctus* Gr.

*Crocigrapha* Gr.—type *normani* Gr.

*Aplecta* Gn.—type *nebulosa* Hufn.

*Eriopyga* Gn.—type *punctulum* Gn.

Pseudorthodes Morr.—*vecors* Gn.

Naesia Walk.—type *moesta* Walk.

Borolia Moore—*furcifera* Moore.

Meliana Curtis—*flammea* Curt.

Heliophila Hub.—*pallens* Linn.

These genotypes may be separated more or less satisfactorily in the following way:

A. Primaries with the costal margin slightly convex.

1. Legs compactly scaled ..... Meliana  
Some of the segments of the legs bearing hair and scales ..... 2
2. Apex of the primaries drawn to a point ..... Eriopyga  
Apex truncated ..... 3
3. All palpal segments bearing scales only ..... Borolia  
Some palpal segments bearing hair and scales ..... Naesia

B. Primaries with the costa straight.

1. Vestiture of the head hair only ..... Heliophila  
Vestiture of the head hair and scales or scales ..... 2
2. No dorsal abdominal crests, wings short and stubby.

Pseudorthodes

Dorsal abdominal crests present, wings narrower.....Hadena group

Meliana, Eriopyga, Borolia and Naesia

These four genotypes are grouped together on the basis of their convex costal margin. Meliana can be separated from the other three on the vestiture of the legs. All the legs of *Meliana flammea* are compactly scaled which is not a common character in this sub-family. The other three genotypes in this group have some portion of some of the legs covered with a mixture of hair and scales. *Meliana flammea* is a European species and the genus may be represented in this country. *Borolia furcifera* comes from India and is the type of a genus which is considered to be synonymic with Meliana. The closely scaled legs in Meliana would separate it from Borolia. Borolia however may stand very close to our genus Heliophila from which it differs in the form of the costal margin of the fore wing-convex in Borolia, straight in Heliophila. *Eriopyga punctulum* Gn. and *Naesia moesta* Walk. are both South American species typical of genera which have been confused with Himella and Pseudorthodes. Pseudorthodes with its short stubby wings, and Himella in which the antenna of the male is crenulated can not be confused with their South American neighbors.

## Synopsis of Morphological Characters

	Eriopyga	Naesia	Borolia ♀	Meliana
Head:				
Vestiture .....	2	3	3	2
Compound eyes .....	3	3	3	3
Frons .....	1	1	1	1
Antenna of the male .....	2 hair and lateral setae	2 hair and lateral setae	×	2 hair and lateral setae
Antenna of the female .....	1 cilia and lateral setae	1 cilia and lateral setae	1 cilia and lateral cilia	1 cilia, lateral mid ventral setae
Vestiture of the palpi .....	2	4	2	2
Ratio of the palpal segments .....	×	2	3	3
Proboscis .....	1	1	1	1
Thorax:				
Vestiture .....	2	2	2	1
Crests .....	2	3	2	1
Costa of primaries .....	3	3	3	3
Apex of primaries .....	3	1	1	3
Outer margin of primaries .....	incurred	incurred	incurred	incurred
Sc. and R. of the secondaries .....	×	1	2	2
Vestiture of legs .....	1	1	1	2
Structure of legs .....	1	1	1	1
Abdomen:				
Vestiture .....	4	4	4	4
Dorsal crests .....	3	1	1	1
Lateral crests .....	1	1	1	1

### Heliophila Hubner

The type of this genus is the European species *pallens* of Linnaeus. The genus is well represented in this country but many of the species are difficult to identify because they resemble each other so markedly. The genus *Leucania* of Oechsenheimer has *pallens* as its type so it sinks as a synonym of *Heliophila*.

#### Synopsis of Morphological Characters

##### Head:

Vestiture 1, Compound eyes 3, Frons 1, Antenna of the male 2 with hair and lateral setae, in the female 1 ciliated with lateral setae, Vestiture of the palpi 2, Ratio of the palpal segments 2, Proboscis 1.

##### Thorax:

Vestiture 2, Crests 1, Costa of the primaries 1, Apex of primaries 3, Outer margin of primaries straight, Sc. and R. of the secondaries 2, Structure and vestiture of all legs 1.

##### Abdomen:

Vestiture 4, Dorsal crests 1, Lateral crests 1.

### Pseudorthodes Morrison

This genus has for its type the American species *vecors* Guenee. In many ways it resembles morphologically the genus *Crociographa* but the shorter more stubby wings of *vecors* will serve to separate the two genera.

#### Synopsis of Morphological Characters

##### Head:

Vestiture 2, Compound eyes 3, Frons 1, Antenna of the male 2 short hair and lateral setae, in the female 1 ciliated with lateral setae, Vestiture of palpi 4, Ratio of the palpal segments 1 and in some specimens 2, Proboscis 1.

##### Thorax:

Vestiture 2, Crests 3, Costa of the primaries 1, Apex of the primaries 2, Outer margin of primaries straight, Sc. and R. of the secondaries 1, Vestiture and structure of all legs 1.

##### Abdomen:

Vestiture 4 in one female 7, Dorsal crests 1, Lateral crests in the male 3, in the female 1.



### The Hadena Group

Associated with *Hadena* are seven other genera all of which have much in common with *Hadena*. One is tempted to separate them on the basis of coloration and marking but if we try to establish genera on purely morphological characters then some, if not all, of the six genera will have to sink as synonyms of *Hadena*. Of the eight genotypes three are North American species—*Dargida grammivora*,\* *Crocigrapha normani*, and *Eupsephopaectes procinctus*. The other five are European. Below is a synopsis of morphological characteristics of the eight types and the reader may use his own judgment as to which ones, if any, he wishes to consider valid and which he will look upon as synonymic with *Hadena*.

A summary of the morphology of the four European genera is presented in tabular form.

*Dargida* differs from *Hadena* in having two palpal segments bearing scales only, one thoracic crest, outer margin of the primaries incurved, and dorsal abdominal crests indistinct. *Eupsephopaectes* can be separated from *Hadena* in the following ways—vestiture of head scales, proximal and middle palpal segments bearing only scales, vestiture of the thorax hair and scales, and one dorsal abdominal crest. *Crocigrapha* shows many points of difference when compared with *Hadena*. *Crocigrapha* has the proximal and middle segments bearing scales only, vestiture of the thorax hair and scales, indistinct pro- and a more evident meta-thoracic crests, apex of the primaries rounded, abdomen covered dorsally and ventrally with hair and scales, and a single dorsal abdominal crest. These may be sufficient reasons for considering the three genera distinct from *Hadena*.

#### Subsection II Antenna of the Male Never Filiform

In this section are twelve genotypes the males of which have antennæ that vary from crenulate to bipectinate. All of these are quite distinct with the exception of *Monostola* which stands very close to our American genus *Nephelodes*. The twelve genera, their genotypes, and the habitat of the genotypes are presented.

\* *gramminivora* (lapsus calami).

## Synopsis of Morphological Characteristics

	Hadena	Dargida	Eupsephopaetes	Crocigrapha
Head:				
Vestiture .....	2	2	3	2
Compound eyes .....	3	3	3	3
Frons .....	1	1	1	1
Antenna of male .....	2 hair and lateral setae	as in Hadena	as in Hadena	as in Hadena
Antenna of female .....	1 cilia and lateral setae	as in Hadena	as in Hadena	as in Hadena
Vestiture of palpi .....	3	4	4	4
Ratio of palpal segments .....	3	3	2	2
Proboscis .....	1	1	1	1
Thorax:				
Vestiture .....	3	3	2	2
Crests .....	5	2	5	3
Costa of the primaries .....	1	1	1	1
Apex of primaries .....	1	1	1	2
Outer margin of primaries .....	straight	incurved	straight	straight
Sc. and R. of the secondaries .....	2	1	2	1
Vestiture and structure all legs .....	1	1	1	1
Abdomen:				
Vestiture .....	4	5♂ 4♀	4	6
Dorsal crests .....	7	2	4	3
Lateral crests .....	3♂ 1♀	3♂ 1♀	3	3

## Synopsis of Morphological Characteristics

	Aethria	Astrapetis	Diataraxia	Aplecta
Head:				
Vestiture .....	2	2	3	3
Compound eyes .....	3	3	3	3
Frons .....	1	1	1	1
Antenna of male .....	2 hair no setae	as in Hadena	as in Hadena	2 ciliated lateral setae as in Hadenia
Antenna of female .....	as in Hadenia	as in Hadenia	as in Hadenia	
Vestiture of palpi .....	4	4	4	2
Ratio of palpal segments .....	2	2	3	2
Proboscis .....	1	1	1	1
Thorax:				
Vestiture .....	3	2	2	3
Crests .....	4	3	5	5
Costa of primaries .....	1	1	1	1
Apex of primaries .....	2	1	1	1
Outer margin of primaries .....	straight	incurved	straight	straight
Sc. and R. of secondaries .....	2	2	2	2
Vestiture and structure all legs .....	1	1	1	1
Abdomen:				
Vestiture .....	6	2♂ 4♀	4	6
Dorsal crests .....	2	7	7	3
Lateral crests .....	2	3♂ 2♀	2	1

Morrisonia Grote—type <i>evicta</i> Grt. ....	U. S. A.
Xylomyges Gn.—type <i>conspicillaris</i> Linn. ....	Europe
Himella Grt.—type <i>fidelis</i> Grt. ....	U. S. A.
Alysia Gn.—type <i>specifica</i> Gn. ....	Australia, New Zealand
Hyperepia Barnes & Lindsey—type <i>pi</i> B. & L. ....	U. S. A.
Nephelodes Gn.—type <i>emmedonia</i> Cram. ( <i>minians</i> Gn.) ....	U. S. A.
Monostola Alpheraky—type <i>asiatica</i> Alph. ....	Asia
Charaeas Steph.—type <i>cespitis</i> W. V. ....	Europe
Haderonia Staud.—type <i>subarschanica</i> Staud. ....	Europe
Epineuronia Staud.— <i>popularis</i> Fab. ....	Europe
Acerra Grt.— <i>normalis</i> Grt. ....	U. S. A.
Stretchia Hy. Edw.—type <i>plusiaeformis</i> Hy. Edw. ....	U. S. A.

#### Remarks

A word or two regarding some of these genotypes may clear up a few questions in the mind of the reader. Both Smith and Guenee allowed some range of variation in the type of antenna to be found in the genus *Xylomyges*. Probably it would be best to restrict the genus to those species in which the antenna of the male is serrated. Hampson would place *conspicillaris* under the genus *Xylomania* but in the structure of the antenna of the male and female they are both quite distinct.

In the case of *Alysia*, Hampson would combine it with *Ulolonche* and make them synonymous with *Hyssia*. In the type of male antenna, *Alysia* is distinctive and probably stands close to our American genus *Himella*.

*Nephelodes* has at least one synonym—*Monosca* Walker. *Monosca*, like many of Walker's genera, is a monotypical genus with *subnotata* Walker as its type. According to Hampson *subnotata* Walker is a synonym of *emmedonia* Cramer (*minians* Gn.) so both *Nephelodes* and *Monosca* have the same genotype. *Monostola asiatica* is in coloration and marking very much like *emmedonia* but structurally there are some differences. The most outstanding differences are in the vestiture of the head, type of antennae in the males, development of the proboscis, and thoracic crests.



# Synopsis of Morphological Characters

	<i>Morrisonia</i> <i>evicta</i> Grt.	<i>Xylomyges</i> <i>conspicillaris</i> W. V.	<i>Himella</i> <i>fidelis</i> Gr.	<i>Alysia</i> <i>specifica</i>	<i>Hyperopia</i> <i>pi</i> B. & L. ♂	<i>Nephelodes</i> <i>minvians</i> Gn.	<i>Monostola</i> <i>asiatica</i> Alph. ♂	<i>Characae</i> <i>cespitis</i> W. V.	<i>Haderonia</i> <i>subarschamica</i> Staud.	<i>Epineuronia</i> <i>popularis</i> Fab.	<i>Acerva</i> <i>normalis</i> Grt.	<i>Stretchia</i> <i>plusiaeformis</i> H. Edw.
Head:												
Vestiture .....	2	2	2	1	3	2	1	2	2	2	1	2
Compound eyes .....	3	3	3	3	3	3	3	3	3	3	3	3
Frons .....	1	1	1	1	1	1	1	1	1	1	1	1
Antenna of male .....	5	4	6	7	12	11	23	20	14	24	15	13
Antenna of female .....	1	1	1c	1a	×	1b	×	1	1	3	5	8
Vestiture of palpi .....	4	4	4	4	4	2	4	4	4	2	2	5
Ratio of palpal seg. ....	2 and 3	2	1	2	2	2	2	2	1	2	1	2
Proboscis .....	1	1	1	1	1	1	2	2	1	2	1	1
Thorax:												
Vestiture .....	3	3	2	1	3	2	1	3	3	2	1	2
Crests .....	5	5	1	1	5	5	1	5	5	1	5	5
Primaries—costa .....	1	1	3	1	1	1	1	1	1	1	1	1
“ —apex .....	1	3	1	1	1	1	1	1	2	1	3	2
“ —outer margin .....	straight	straight	straight	incurved	straight	straight	straight	2	incurved	straight	slightly incurved	slightly incurved

# Synopsis of Morphological Characters

	<i>Morrissonia</i> <i>evicta</i> Grt.	<i>Xylomyges</i> <i>conspicillaris</i> W. V.	<i>Himella</i> <i>fidelis</i> Gr.	<i>Alysia</i> <i>specifica</i>	<i>Hyperopia</i> <i>pi B. &amp; L.</i> ♂	<i>Nephelodes</i> <i>minimus</i> Gn.	<i>Monostola</i> <i>asiatica</i> Alph. ♂	<i>Characas</i> <i>cespitis</i> W. V.	<i>Haderonia</i> <i>subarschamica</i> Staud.	<i>Epineuronia</i> <i>popularis</i> Fab.	<i>Acerua</i> <i>normalis</i> Grt.	<i>Strechia</i> <i>plusiaeformis</i> H. Edw.
Secondaries Sc. & R	2	1	1	1	2	2	1	1	1	1	1	1
All legs—structure	1	1	1	1	1	1	1	1	1	1	1	1, seenote
“ “ —vestiture	1	1	1	1	1	1	1	1	1	1	1	1
Abdomen:												
Vestiture	6	6	5♂ 4♀	2	4	4	6	4	6	6♂ 4♀	6	6
Dorsal crests	1♂ 3♀	3	1	1	3	4♂ 2♀	4	4♂ 2♀	6	3	3	3
Lateral crests	3♂ 1♀	3	3♂ 1♀	3	3	3♂ 1♀	1	1	1	3	3♂ 1♀	3♂ 1♀

Female antenna: (1) Filiform fine cilia beneath with lateral setae, (1a) as in (1) but flattened beneath, (1b) as in (1) but with mid ventral setae also, (1c) ventral surface covered with short hair lateral setae.

These would serve to separate *Nephelodes* from *Monostola* but the two genera are very closely related.

*Charaeas* has been included because some writers have confused it with *Mamestra*. In the structure of the fore tibia, the type of male antennae, and other more minor differences the two genera are very distinct. *Charaeas* belongs here with this group of genera although it may not be represented in this country.

*Haderonia* has also been confused with *Mamestra* but a comparison of the two genotypes will serve to separate them easily.

*Acerra*, *Stretchia*, and *Perigrapha* are three genera very closely related and often confused. *Perigrapha* has been removed from this section on the basis of its frons. *Acerra* and *Stretchia* show some points of difference particularly in the form of the antennae of the male and female. *Perigrapha* serves as a link to connect this section with Section B.

### Section B

The genotypes in this section are characterized by having the frons of various forms but never uniformly rounded. This section can be subdivided into two subsections as follows: Subsection I frons produced but not ornamented, and Subsections II frons bearing some form of ornamentation.

#### Subsection I

Subsection Ia Antenna of the male never simple.

In this section the writer has placed the following genera:

<i>Perigrapha</i> Lederer	type <i>i-cinctum</i> Schiff.	Europe
<i>Xylomania</i> Hampson	type <i>hiemalis</i> Grote	U. S. A.
<i>Engelhardtia</i> Barnes	type <i>ursina</i> Smith	U. S. A.
<i>Lasiestra</i> Hampson	type <i>phoca</i> Morsch.	North America
<i>Eurypsye</i> Butler	type <i>similis</i> Butler	India

*Perigrapha* has many of the characteristics of *Acerra* and *Stretchia* but the slightly protuberant frons places it in this section. It serves to connect Sections A and B. *Eurypsye* resembles *Meliana* in many respects but the shape of the frons and structure of the antennae of the male of this Indian genus removes it from *Meliana* section.

## SECTION B

	Subsection Ia			Subsection Ib								
	<i>Perigrappa</i> <i>i-cinctum</i> Schiff.	<i>Xylomania</i> <i>hiemalis</i> Grote	<i>Engelhardtia</i> <i>ursina</i> Smith	<i>Lasiestra</i> <i>phoca</i> Mosch.	<i>Eurypsiche</i> <i>sumilis</i> Butler	<i>Cardipia</i> <i>virrisor</i> Ersch	<i>Trichocosmia</i> <i>inornata</i> Grote	<i>Barathra</i> <i>albicolon</i> Ochs	<i>Scotoqramma</i> <i>submarina</i> Grote	<i>Dianthoezia</i> <i>carpohaga</i> Bork.	<i>Sideridis</i> <i>evidens</i> Hub.	<i>Neuria</i> <i>reticulata</i> Linn.
Head												
Vestiture .....	1	3	1	1	3?	2	3	2	1	2	2	2
Compound eyes .....	3	3	3	3	3	3	3	3	3	3	3	3
Frons .....	2	2	2	2	2	2	2	2	2	4	3	3
Antennæ of male .....	21	18	16	8	3	2a	1a	1	1c	1d	1d	2a
Antennæ of female .....	8	7	6	1a	x	1b	1c	1a	1b	1b	1b	1b
Vestiture of palpi .....	4	5	4	4	1	4	2	4	4	3	2	4
Ratio of palpal seg. ....	1	1 and 2	2	3	3	♂♂3♀	2	2	2	3	2	1
Proboscis .....	2	1	2	1	1	1	1	1	1	1	1	1
Thorax												
Vestiture .....	1	2	1	1	3	3	3	2	2	3	1	3
Crests .....	5	5	1	1	1?	1	5♂4♀	6	5	5	3	5
Costa of primaries .....	1	1	1	2	3	1	1	1	1	1	1	1
Apex of primaries .....	1	3	3	1	3	2	2	1	2	1	1	1



# SECTION B

	Subsection Ia				Subsection Ib							
	<i>Perigrappa</i> <i>incinctum</i> Schiff.	<i>Xylomania</i> <i>hiemalis</i> Grote	<i>Engelhardtia</i> <i>ursina</i> Smith	<i>Lasiestra</i> <i>phoca</i> Mosch.	<i>Eurypsyche</i> <i>similis</i> Butler	<i>Cardipia</i> <i>viridis</i> Ersch	<i>Trichocosmia</i> <i>inornata</i> Grote	<i>Barathra</i> <i>albicollis</i> Ochs	<i>Scotogramma</i> <i>submarina</i> Grote	<i>Dianthoecia</i> <i>carpophaga</i> Bork.	<i>Sideridis</i> <i>evidens</i> Hub.	<i>Neuvia</i> <i>reticulata</i> Linn.
Outer margin of primaries .....	2	1	1	2	2	2	2	1	2	1	2	2
Secondaries Sc. & R. ...	1	1	1	1	2	1	2	1	1	1	1	2
Vestiture of all legs ...	1	1	1	1	1	1	1	1	1	1	1	1
Structure of all legs ...	1	1	1	1	1	1	1	1	1	1	1	1
Abdomen												
Vestiture .....	7	6	6	6	x	4	7	3	4	4	4	4
Dorsal crests .....	3	3	1	3	x	2	3	3	3	3	3	3
Lateral crests .....	3	3	1	2♂ 1♀	x	2	1	1	1	3♂ 1♀	2	3♂ 1♀

Antenna of male 1a = hair, lateral no mid ventral setae; 1b as in 1a but with mid ventral setae; 1c hair no setae; 1d hair lateral setae; 2a wedge shaped, long hair, lateral setae.  
 Antenna of female—1a = ciliated, lateral and mid ventral setae; 1b ciliated lateral setae only; 1c short hair, lateral, one mid ventral setum.

## SECTION B

Subsection IIa		Subsection IIb
<i>Xanthopastes tinias</i> Cram.	<i>Craterestra lucina</i> Druce	<i>Discestra chartaria</i> Grote
		<i>Cea immacula</i> Grote
		<i>Trichoclea decepta</i> Grote
		<i>Ichneutica cernanias</i> Meyrick
		<i>Midodera stigmata</i> Smith
Head		
Vestiture .....	2	4
Compound eyes .....	3	3
Frons .....	7	9
Antennæ of male .....	1a	17
Antennæ of female .....	1	3
Vestiture of palpi .....	5	4
Ratio of palpal seg. ....	2	1
Proboscis .....	2	1
Thorax		
Vestiture .....	2	3
Crests .....	4	2
Costa of primaries .....	3	1
Apex of primaries .....	2	2

## SECTION B

	Subsection IIa				Subsection IIb		
	<i>Xanthopastes</i> <i>tinnius</i> Gram.	<i>Graterestra</i> <i>lucina</i> Druce	<i>Discestra</i> <i>chartaria</i> Grote	<i>Cea</i> <i>innacula</i> Grote	<i>Trichoclea</i> <i>decepta</i> Grote	<i>Ichneutica</i> <i>cervina</i> Meyrick	<i>Modera</i> <i>stigmata</i> Smith
Outer margin of primaries .....	straight	incurred	incurred	incurred	straight	straight	incurred
Sc. and R. of secondaries .....	2	x	1	1	1	1	1
Vestiture of all legs .....	1	1	1	2	1	1	1
Structure of all legs .....	1	1	1	1	1 (see Note)	1	1
Abdomen							
Vestiture .....	4	4	4	7	4	1	6
Dorsal crests .....	3	6	3	3	3	3	2
Lateral crests .....	1	2	2	1	2	3	1

Note: In one pair of *Trichoclea decepta*, the fore legs had type 4 structure.

Antenna of Male 1a, hair no setae; 1b, hair lateral setae; 2a, wedge shaped hair no setae; 2b, wedge, lateral setae; 2c, wedge ciliated lateral setae.

Antenna of Female 1 ciliated with lateral setæ.

### Synopsis of Morphological Characters (See Chart)

Subsection Ib Antenna of the male filiform (simple).

In this section the writer places the following:

Cardepia Hampson	type <i>irrisor</i> Ersch	Russia, Turkestan
Trichocosmia Grote	type <i>inornata</i> Grote	U. S. A.
Barathra Hubner	type <i>albicolon</i> Ochs	Europe
Scotogramma Smith	type <i>submarina</i> Grote	U. S. A.
Dianthœcia Boisd.	type <i>carpophaga</i> Bork.	Europe
Sideridis Hubner	type <i>evidens</i> Hubner	Europe
Neuria Guenee	type <i>reticulata</i> L. (saporariæ De.G.)	Europe

#### Remarks

Barathra is included here because many writers make it a synonym of Mamestra. Their reason is based on the fact that they consider brassicæ the types of both genera. *Brassicæ* is the type of Mamestra but *albicolon* is the type of Barathra by elimination. *Albicolon* does not have the claw on the fore tibia and cannot be included in Mamestra.

#### Subsection II

In this subsection the genotypes have the frons either ornamented or excavated. They fall naturally into two groups on the bases of the antennæ of the male.

##### Subsection IIa

The males in this subsection have some form of simple antennæ. The frons may bear a knob-like protuberance or some type of heart-like prominence. So far as the writer knows, the antennæ of the female is always simple. All of the genera are American and their types are to be found in the United States. For a more detailed discussion of the other morphological characteristics the reader is referred to the chart. *Regnatrrix* Grote is the same as *timais* Cramer, so *Philochrysa* is a synonym of *Xanthopastes*, both genera having the same species for their types.

##### Subsection IIb

In this subsection neither males nor females have simple antennæ. Here the writer places two genera:



Ichneutica Meyrick	Type <i>ceraunias</i> Meyrick	New Zealand
Miodera Smith	Type <i>stigmata</i> Smith	U. S. A.

Incheutica has been included in this article because it has been considered by some as being synonymic with the genus *Leucania*. In the shape of the frons, and in the structure of the antennæ of the male, it is quite distinct and probably has no representatives in this country. For more details concerning the morphology of these genotypes see the chart.

### The Male Genitalia

A study of the male genitalia was made wherever material was available. There is no doubt that these structures exhibit some characteristics of generic value but many of the differences between male genitalia are purely specific and not generic. In order to separate the specific from the generic one should study the genitalia of all the species of all the genera included in this article. Since it was not possible to do this, the writer has not attempted to use the genitalia in his classification. They should, however, form a working basis for future study.

In describing the various parts the writer has followed the nomenclature of F. N. Pierce in his excellent article, "The Genitalia of the Noctuidæ." Pierce's terminology (with modifications from Walker and Crampton) is as follows:

**Uncus:** (Epiandrium or Epiproct in part) This is a dorsal appendage of the tenth somite. It may be simple, cygnated, tongue shaped, diamond form, spatulate, or forked (mandibulate).

**Peniculus:** a lobed process on either side of the tegumen which bears a brush of long hair.

**Scaphium:** a process on the upper side of the anus.

**Subscaphium:** a process attached to the lower surface of the anus.

**Harpe:** (Gonapophyses or Gonostyli) Two wing like projections one on each side below the tegumen. The most distal portion Pierce calls the Cucullus. This may be peaked, bifurcate, trigonate, or rounded—the latter term includes the battledore type of Pierce.

Corona: a row of incurved spines at the distal margin of the Harpes.

Marginal Spines: long slender spines on the distal margin of the Harpes.

Protuberances: this term includes the clasper and ampulla arising from the Harpe.

Editum: a finely spined prominence arising usually near the ampulla. This is not always easy to show in the figures.

Clavus: a prominence arising from the base of the Harpe. It may be brush form, rounded, produced, or scobinated.

Ædæagus: the penis sheath which may be ornamented anywhere along its length or at the orifice.

Vesica: an eversible sac sometimes provided with spines or cornuti or other ornamentation. This is not always easy to see, for it may be turned back into the ædæagus.

Juxta: (Pseudosternite ?) Beneath the anal aperture a sheath through which the ædæagus passes. Sometimes this sheath is heavily sclerotized.

Vinculum: (The ninth sternite) A ventral sclerotized band or ring.

#### Group I

*Mamestra brassicæ* Linn. Fig. 4B.

Uncus—tongue shaped; Peniculus—present; Scaphium—slight indications of its presence; Subscaphium—also slightly evident; Harpe—trigonal; Marginal spines—absent; Corona—present; Protuberance—a flap attached to the Harpe; Editum—present; Clavus—slightly produced; Ædæagus—orifice with a hook on one side; Vesica—probably bearing two small cornuti.

#### Group II

Of the three genotypes included in this group, the genitalia of only two can be illustrated and described.

*Ommatostola lintneri* Gr. Fig. 12A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—tends to be trigonal; Marginal spines—present; Corona—present; Protuberances—a very small, poorly chitinized rod and a stiff curved strap; Editum—present;

Clavus—rounded; *Ædæagus*—orifice scobinated on one side; Vesica—not ornamented.

*Buchholzia colorada* Sm. Fig. 16A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—flattened, very irregular along its edge; Pollex—present; Marginal spines—a few; Corona—a partial; Protuberances—a weak rod and a thick sclerotized rod; Editum—present; Clavus—produced and bearing a curved strap-like organ; *Ædæagus*—orifice provided with a hook laterally; Vesica—with a band of teeth.

### Group III

Four genera constitute this group but only three of them can be figured. The genitalia of *artega* Barnes and *semiaperta* Morr. show marked resemblances in the shape of their harpes while *dentatella* Grote seems to stand off by itself.

(*To be concluded*)

*The Biological Control of Insects with a Chapter on Weed Control.* By Harvey L. Sweetman, Ithaca, N. Y., Comstock Publishing Company, Inc., 1936. xii + 460 pp. 142 figs. \$3.75.

DeGeer, it is recorded, once made the statement before the Academy of Sciences at Stockholm, that, "We shall never be able to guard ourselves against insects but by means of other insects." There is no doubt about entomologists in general, with the possible exception of some investigators holding different opinions, welcoming a book covering a subject that is not only popular but of scientific and practical interest as well. This is the first time that the literature of biological control has been brought together and summarized, and such summaries are of distinct value not only to scientists and specialists who are familiar with the literature, but to students, in giving them a broad background.

Dr. Sweetman's book covers the theoretical basis of biological control, the use of resistant hosts, the use of bacteria, fungi, viruses, protozoa, nematodes, parasitic insects and predatory invertebrate animals, and there are chapters on the use and introduction of insect parasites and predators, the results of biological control experiments and the biological control of pest plants. In all there are fourteen chapters, a glossary, a list of references and an index.

To those occupied with specific phases of investigational work related to biological control, Dr. Sweetman's accounts may seem to be unduly condensed, but it should be remembered that such curtailment was necessary in view of the size of his field. It should also be remembered that in some phases, the conclusions of experimental work are in a more or less fluid state and that new facts are constantly being developed. For example, the artificial culture of *Neoplectana glaseri* is now taking place, not on a potato medium, but on a medium of ground veal, which at present appears to be quite successful and which has distinct advantages over the potato medium. Such changes in technique, however, frequently take place quite suddenly, and can only be incorporated into future editions of text books.

That there is much more to biological control than the mere introduction and dissemination of beneficial species is plainly brought out in Dr. Sweetman's work. It is somewhat discouraging to note, in his chapter on results, that what he considers highly successful control, and successful control, in the United States, have so far been confined to only three cases in California. For example, as far as adequate results are concerned, the biological control of the gypsy moth in this country is still in the experimental stage. Of course, biological control is young. It has very little early history and in years to come, when accurate and adequate data have accumulated, and when true conclusions can be drawn, it may be possible to study such cases comparatively and to arrive at some basic conclusions relative to where and under what conditions biological control is likely to be successful.

Dr. Sweetman's book is carefully and thoughtfully written, and should appeal to all entomologists and teachers of entomology who are anxious to add to their store of information. H. B. W.



## THE EFFECT OF SOAP SPRAYS ON PLANTS\*

JOSEPH M. GINSBURG, PH.D.

BIOCHEMIST IN ENTOMOLOGY,

and

CLAYTON KENT,

LABORATORY ASSISTANT,

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

### INTRODUCTION

Soaps in concentration of from 0.1 per cent to 0.5 per cent are at present widely used as spreading and wetting agents with contact poisons such as nicotine (4), pyrethrum (2), derris (3) and others. In concentrations of 1.0 per cent or stronger soap is sufficiently toxic to kill many soft bodied insects and their larvæ (1, 5). High kill of the Japanese beetle was also obtained with 1 per cent and 1.5 per cent soap solutions, as reported by van der Meulen and van Leeuwen (7) and others. Not all plants, however, can stand such high concentrations of soaps. It therefore became important to ascertain the maximum soap concentration that may be sprayed on different plants without injury. Since cocoanut oil soap has been shown to possess (6, 7) higher insecticidal properties than other soaps, potassium cocoanut oil soap was selected for testing. In addition to its higher toxic properties, cocoanut oil soap can be prepared in liquid form containing about 40 per cent actual soap and is readily soluble in cold water. These features make the soap more convenient to apply than the semi-solid soaps which require long standing or heating in order to dissolve in water.

### EXPERIMENTAL

Some 54 different varieties including garden, orchard, greenhouse and ornamental plants were sprayed with aqueous solutions of 0.25, 0.5, 1.0 and 2.0 per cent cocoanut oil soap. The spray was applied with a 3 gallon knapsack sprayer. Observations were

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made within two weeks following the spray application. The tests on the outdoor plants were carried out between the 12 and 26 of August, 1932. During this period only two very light rainfalls occurred in the vicinity where the testing was conducted, giving a total precipitation of 0.34 inch. The foliage on the greenhouse plants was not syringed with water during the experiments.

The results, presented in tables 1 and 2 show that 0.25 per cent and 0.5 per cent soap produced no injury to any one of the plants tested; one per cent soap produced injury to 8 varieties of greenhouse plants, 7 varieties of garden plants but none to orchard trees; two per cent soap caused injury to most of the plants ranging from slight to severe.

Following these results it became of interest to study the effect of soap on blossoms. For this purpose 16 ornamental plants in full bloom were sprayed with 0.25 per cent and 0.5 per cent soap. The results in table 3 show that no injury resulted to the flowers

TABLE 1. TESTS WITH VARIOUS CONCENTRATIONS OF COCOANUT OIL SOAP ON GREENHOUSE PLANTS

Name of Plant	Injury from 0.25% & 0.5% Soap	Injury from 1% Soap	Injury from 2% Soap
Begonia .....	None	None	Slight injury to leaves.
Buddleia .....	"	Injury to young leaves.	Severe injury.
Crassula .....	"	None	None
Carnation .....	"	"	Injury to stems & leaves.
Chrysanthemum .....	"	"	None
Dracena .....	"	"	"
Euphorbia .....	"	Injury to young leaves.	Severe injury.
English Ivy .....	"	Injury to young leaves.	Injury to leaves.
Fern (Boston) .....	"	Injury to leaves.	Severe injury to leaves.
Fern (Whitmanii) .....	"	Injury to leaves.	Severe injury to leaves.
Hydrangia .....	"	None	Slight injury.
Poinsettia .....	"	"	Severe injury.
Snapdragon .....	"	Injury to leaf tips.	" "
Stevia .....	"	None	None

of any one of the plants sprayed with 0.25 per cent, while injury occurred on several varieties from the 0.5 per cent solution.

It appears therefore that coconut oil soap in concentrations of 0.5 per cent or lower is practically safe to apply on all kinds of plants with the exception of delicate blossoms. When sprays of higher soap concentrations are required it becomes necessary to consider each variety separately, otherwise the less resistant plants may be injured.

TABLE 2. TESTS WITH VARIOUS CONCENTRATIONS OF COCOANUT OIL SOAP ON ORCHARD AND GARDEN PLANTS

Name of Plant	Injury from 0.25% & 0.5% Soap	Injury from 1% Soap	Injury from 2% Soap
Apple .....	None	None	None
Peach .....	"	"	Slight injury to foliage.
Cherry .....	"	"	Slight injury to foliage.
Grape .....	"	"	Appreciable in- jury to shoots & foliage.
Beets .....	"	"	None
Cabbage (red) .....	"	"	"
Cabbage (green) .....	"	"	"
Kohl-rabi .....	"	"	"
Corn .....	"	"	"
Cucumber .....	"	"	"
Cantaloupe .....	"	"	"
Egg Plant .....	"	No injury.	Injury to blos- soms, none to leaves.
Lettuce .....	"	Injury to leaves.	Severe injury.
Lima Beans .....	"	None	None
Pumpkin .....	"	Injury to foliage.	Injury to foliage.
Blackberries .....	"	Injury to foliage & young shoots.	Injury to foliage & young shoots.
Sweet Potatoes .....	"	No injury.	Slight injury to foliage.
Squash .....	"	None	None
Rose .....	"	"	Injury to young leaves & flow- ers.
String Beans .....	"	Slight injury to young leaves.	
Sweet Peas .....	"	Slight injury to young leaves.	
Tomato (young plants)	"	None	Slight injury.
Tomato (plant in blos- som) .....	"	"	Injury to blos- soms.
Peppers .....	"	Injury to leaves.	Injury to leaves.

TABLE 3. TESTS WITH COCOANUT OIL SOAP ON FLOWERING PLANTS IN BLOOM

Name of Plant	Injury from 0.25% Soap	Injury from 0.5% Soap
Canna .....	None	None
Chrysanthemum, Hardy .....	"	"
Dahlia, Dwarf .....	"	"
Daisy .....	"	"
Delphinium .....	"	Injury to flowers.
Geranium .....	"	None
Geranium, Sweet .....	"	"
Heliotrope .....	"	"
Hollyhock .....	"	Injury to flowers.
Ice Plant .....	"	Injury to flowers.
Marigold .....	"	None
Petunia .....	"	Injury to flowers.
Phlox .....	"	None
Ragged Sailor .....	"	"
Roses .....	"	"
Gladiolus .....	"	Injury to flowers.

## SUMMARY AND CONCLUSIONS

Greenhouse, garden, ornamental and orchard plants were sprayed with various concentrations of cocoanut oil soap in order to determine the maximum concentration that can be applied without injury. The results suggest the following conclusions.

1. Concentrations of 0.25 per cent soap caused no injury to blossoms or foliage of any one of the plants tested.

2. Concentrations of 0.5 per cent soap produced no injury to foliage, stems or buds but caused injury to delicate flowers.

3. Concentrations of 1.0 per cent soap produced no injury to orchard trees but produced injury to many greenhouse and garden plants.

4. Concentrations of 2.0 per cent soap produced injury to most of the plants tested.

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This is a compendium prepared coöperatively by American zoologists under the direction of a committee from Section F of the American Association for the Advancement of Science. This committee consisted of Paul S. Galtsoff, Frank E. Lutz, Paul S. Welch, and James G. Needham, Chairman. Would that all committees could justify their existence by such a useful work as this, although I am not sure which group should be commended the more, the committee of four, or the 186 different contributors; perhaps both should receive equal praise. This book on culture methods, which has been in the making since 1933, is invaluable to those interested in the rearing of invertebrate animals and in maintaining live specimens in laboratories. Numerous animals are involved in the recommendations. There is an introduction by James G. Needham, an article on the methods of collecting and rearing marine invertebrates in the laboratory, by Paul S. Galtsoff, another on collecting and rearing terrestrial and freshwater invertebrates, by F. E. Lutz, J. G. Needham, and P. S. Welch, and these are followed by over three hundred articles dealing with the culture of animals from protozoa to chordata. This book is of value and interest to almost everybody in the field of applied biology. And I for one am willing to accept gratefully and without criticism the information that is offered by the numerous contributors, all specialists in their fields.

H. B. W.

## SEASONAL TRENDS IN THE RELATIVE ABUNDANCE OF JAPANESE BEETLE POPULATIONS IN THE SOIL DURING THE ANNUAL LIFE CYCLE

BY HENRY FOX

FORMERLY ASSOCIATE ENTOMOLOGIST,  
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE,  
UNITED STATES DEPARTMENT OF AGRICULTURE

### INTRODUCTION

Since 1927 the Japanese Beetle Laboratory at Moorestown, N. J., has conducted, under the immediate supervision of the writer, several series of field surveys to determine the status of Japanese beetle populations in the soil in various parts of the territory known to be generally infested with the insect. One series, designated the "seasonal series," was, in part, planned to show each year the seasonal trends in abundance during the course of the annual developmental cycle of the insect; and another series, called the "periodic series," was designed to show the major changes in population occurring from one year to the next. Only the results obtained in the first series are considered in this paper. However, since these surveys were confined to the section close to the original point of entry of the Japanese beetle into this country, and therefore long subject to infestation, data from a third series of surveys, conducted since 1932 in Salem County, N. J., in cooperation with the New Jersey Department of Agriculture, are also included to show to what extent the same trends hold in more recently infested territory.

### LIFE CYCLE OF THE JAPANESE BEETLE

In its present main distribution area, the developmental cycle of the Japanese beetle begins in the summer of one year with the deposition of eggs in the ground by the adult beetles of one generation and terminates in the summer of the succeeding year with the emergence from the ground of the adult beetles of the next generation. There is thus but one generation a year.

In the vicinity of Philadelphia egg deposition extends from the middle or last of June until well along in October, but the number of eggs laid after September 1 is insignificant compared with the number deposited during July and August. Under the usual summer conditions in this area the eggs hatch in from 2 to 3 weeks, and the resulting larvæ grow rapidly, all but a small proportion attaining their full size by the middle of September. The relatively small number of larvæ hatched late in the season grow more slowly because of the lower temperatures, and hence do not become more than half grown before the oncoming of winter precludes any further growth until the following spring. Such retarded larvæ reach their full growth late in May, when the more advanced larvæ are beginning to pupate. The pupæ normally appear about June 1 and are the dominant stage in the soil during much of that month. Under normal temperatures for that time of year, the pupal stage lasts from 10 to 15 days, and shortly after its appearance the adult beetle works its way up through the soil to the surface of the ground and thence either crawls or flies to near-by vegetation, upon which it begins to feed. In the area under consideration the first adult beetles usually appear above ground between June 10 and 20, though ordinarily they do not become abundant until about July 1.

#### EXPECTED TRENDS IN POPULATION AS JUDGED FROM LIFE HISTORY

From the foregoing it is evident that during the summer all stages of the Japanese beetle are present in the soil, but at other seasons, roughly from September 15 until June 1 of the succeeding year, the population is composed almost or quite exclusively of larvæ, most of which are in the last, or third, larval instar.

Since all but a negligible proportion of the eggs are deposited in the summer, there can be no increase in the insect's population in the soil during the remainder of the annual cycle. Consequently, unless mortality during the summer has been exceptionally heavy, it is to be expected that each year a Japanese beetle population will attain its greatest abundance early in September and that all subsequent changes in numbers will be in the nature of a decrease.



## SEASONAL SERIES OF SURVEYS

*Method of Making a Survey*

In view of the known habitat preferences of Japanese beetle larvæ, which form the predominant stage in the soil-inhabiting populations of the insect, the surveys have been conducted for the most part in permanent grasslands, such as pastures and the "roughs" of golf courses. In such sites it was expected that soil and vegetational conditions would probably remain nearly uniform, thereby making it possible to relate observed changes in population directly to influences associated with the passage of time.

At each point of examination a layer of sod 1 foot square was removed, and the larvæ and other soil-inhabiting stages found in the underlying soil were collected and counted. Several diggings were made over a stated period, and the average number of individuals per digging was then computed. This figure served as an index of the relative abundance of the insect at that point during the period in question.

During the first years of these surveys the examinations of the soil at each station were confined to a small tract of grassy sod, so that any consequent injury to the land, which was privately owned, would be as inconspicuous as possible. It was found, however, that some of the results obtained under such circumstances were far from representative of the general neighborhood, and it thus became necessary at times to shift the site of the examinations. These changes made it questionable how far the results obtained at different times were comparable with one another. To remedy this situation, and since in the meanwhile experience had shown that any sod injury due to the diggings was only temporary, late in 1929 the surveys were extended over much larger areas at nearly all the stations.

*Compilation of Data*

Since this paper is concerned solely with the more general trends in the changes in abundance of Japanese beetle populations occurring during an average single annual life cycle, no attempt is made to describe these features as observed in any specific year. Instead, the results of all, or a fair proportion of, the years for

which records are available are combined for each period into a single average, which therefore serves as an index of the relative abundance of the insect during that period. The results, as given in table 1 and figure 1, *A*, have been summarized from records of beetle abundance covering 7 consecutive years in a group of 8 stations, 4 in New Jersey and 4 in an adjoining section of Pennsylvania, all situated within 12 miles of the beetle's original point of entry into this country. Since, as implied in the preceding paragraph, the surveys during the first 3 years were conducted under less nearly uniform conditions than those conducted later, the results based upon the last 4 years are listed separately in table 1, and graphically shown in figure 1, *B*, to show how far they substantiate the indications afforded by the full series of records.

In this series of surveys the individual records obtained at each station were summarized each year for every half-monthly interval for which records were available, throughout the annual life cycle. This procedure gave, for each interval in any 1 year, a series of 8 averages of the number of individuals occurring beneath 1 square foot of sod. The common average of all 8 stations for each interval was then obtained. From these common averages for each year the general averages over a term of years were obtained, which afford a good index of the relative size of the population at any given time of the year. The general results obtained in this way are listed in table 1 under the heading "Average number of individuals per square foot, observed."

Besides giving the observed averages computed from the field records, together with their probable errors, table 1 also lists the averages as estimated by inspection from graphs<sup>1</sup> of seasonal

<sup>1</sup> The graphs were first drawn free-hand and, with the exception of the left-hand ascending portion covering the first summer, were then adjusted by successive approximations until the algebraic sum of the deviations of the estimated from the observed averages so closely approximated zero that the difference was negligible (Ezekiel, *Methods of Correlation Analysis*, p. 132, 1930). On account of the small size of younger larvæ, which form the predominant stage in the soil during July and August, and the consequent difficulty of finding all of them during an examination of the soil, it is believed that the averages obtained during those months are somewhat lower than those obtained early in the fall; hence the writer feels justified in drawing the graphs of summer abundance through or considerably closer to the higher than

trends based upon the observed averages and the relations, in percentages, that the estimated populations in the different half-monthly periods bear to the maximum average population in the first half of September.

#### DISCUSSION OF RESULTS

Comparison of the percentages listed in table 1, and also of the graphs in figure 1, for the 7- and 4-year series shows a close general agreement as regards the general direction and extent of change at successive intervals throughout the beetle's life cycle.

Perhaps the most noteworthy feature shown is the practical absence of any decrease in the population during the winter, which is generally regarded as the season of heaviest insect mortality. The records of the individual years of this period are, with few exceptions, consistent in this respect. Even after the abnormally cold winter of 1934, the spring surveys revealed in general a beetle population reduced little, if at all, below that found late in the autumn of 1933.<sup>2</sup> Winter therefore seems to have a conserving effect on a Japanese beetle population, tending to maintain it at the general level that it had reached late in the autumn when the larvæ entered hibernation.

Reduction in the population is clearly shown to be coincident with the occurrence of warm weather, and, in so far as it is not caused by the emergence of adults from the ground, which in the area involved usually does not begin much before June 15, is suggestive of biotic agencies as the responsible factor. The conserving action of winter may accordingly be attributed to the inhibiting effect of temperature upon the activities of the associated soil organisms, although it may also be due in part to the relative inaccessibility of the larvæ at this season of the year when, because of the depth at which they hibernate, they are

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to the lower averages (table 1, fig. 1). As a result the algebraic sum of the deviations of the estimates from the observed values shows a marked negative trend (-4.3 in the 7-year series; -1.1 in the 4-year series). The standard error of the estimates is  $\pm 0.85$  in the 7-year series and  $\pm 0.72$  in the 4-year series.

<sup>2</sup> Fox, Henry. Some misconceptions regarding the effects of the cold of February, 1934, on the larvæ of the Japanese beetle, *Popillia japonica* Newman. Jour. Econ. Ent., 28: 154-159. 1935.

TABLE 1. SUMMARY OF SEASONAL SURVEYS TO DETERMINE JAPANESE BEETLE POPULATIONS IN THE SOIL AT HALF-MONTHLY INTERVALS THROUGHOUT THE INSECT'S DEVELOPMENTAL CYCLE

Period <sup>1</sup>	Seven-year series (1927-1934)			Four-year series (1930-1934)		
	Number of square feet examined	Average number of individuals per square foot		Number of square feet examined	Average number of individuals per square foot	
		Observed	Estimated		Observed	Estimated
June 16-30...	1726	.1 ± .04	.1	1246	.2 ± .08	.2
July 1-15...	1359	3.0 ± .40	3.0	816	3.9 ± .42	3.8
16-31...	1592	5.9 ± .69	6.9 <sup>2</sup>	1010	6.7 ± .70	7.0 <sup>2</sup>
Aug. 1-15...	1383	8.3 ± .96	10.9 <sup>2</sup>	846	9.2 ± 1.23	10.2 <sup>2</sup>
16-31...	1469	14.3 ± 1.69	14.9 <sup>2</sup>	845	13.3 ± 2.12	13.4 <sup>2</sup>
Sept. 1-15...	1277	16.9 ± 2.00	16.9	890	14.8 ± 2.63	14.8
16-30...	1342	16.0 ± 1.47	16.0	913	13.7 ± 2.00	13.7
Oct. 1-15...	1630	14.9 ± 1.18	14.9	1138	12.2 ± 1.31	12.3
16-31...	1764	12.5 ± .90	13.9	1223	10.3 ± .68	12.2
Nov. 1-15...	1272	13.6 ± 1.42	13.4	878	11.7 ± 1.17	12.2
Mar. 16-31...	1138	13.4 ± 1.45	12.9	601	12.4 ± 2.23	12.0
Apr. 16-30...	1606	13.4 ± 1.21	12.8	1025	13.0 ± 1.81	11.9
May 1-15...	1688	12.5 ± 1.24	12.5	1012	13.0 ± 2.14	11.8
16-31...	1834	11.2 ± 1.00	11.4	1134	11.1 ± 1.51	11.1
June 1-15...	1937	9.6 ± .77	9.6	1219	9.6 ± 1.26	9.6
16-30...	1785	7.1 ± .68	6.9	1078	6.7 ± 1.07	6.7
July 1-15...	1401	2.8 ± .54	2.8	858	2.0 ± .47	2.0
16-31...	1732	.3 ± .11	.3	1028	.2 ± .03	.2
Aug. 1-15...	1502	.0 ± .01	.0	903	.0 ± .00	.0

<sup>1</sup> The half-monthly periods from June 16 to August 15 are included twice, pertaining in the first place to the early stages in the beetle's developmental cycle, and in the second to the final stages of the same generation when adults are emerging above ground. Records of the periods between November 16 and March 15, and between April 1 and 15 are incomplete.

<sup>2</sup> Graphs of summer populations passing through observed values usually exhibit a pronounced dip or sag in their middle section. Because of the relatively minute size of the earlier larval stages, which predominate during much of the summer, a somewhat larger proportion of them are doubtless missed in the soil examinations than is the case with eggs (conspicuous because of their white color and relative firmness) or older larvae. It accordingly seems justifiable to estimate the populations between mid-July and late August at a somewhat higher value than is indicated by the observed averages. This correction is especially called for in the 7-year series, the earlier surveys of which during the summers were conducted under rather unfavorable conditions.



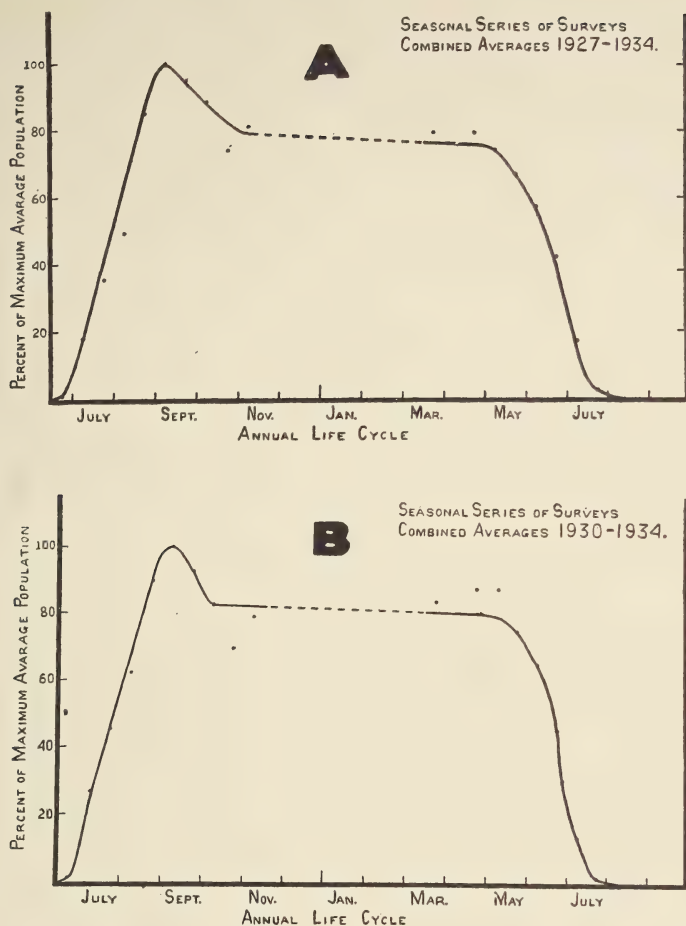


FIGURE 1.—Seasonal trends in the relative abundance of Japanese beetle populations in the soil during the annual life cycle, in percentage of the population for the period September 1-15: *A*, Estimates based upon records of 7 consecutive years (1927-1934) in the seasonal series of surveys; *B*, estimates based upon records of the last 4 (1930-1934) of the 7 consecutive years in the same series of surveys.

largely protected from birds and other animals feeding at the surface.

It is obvious that any mortality in a population during its first summer is normally more than compensated for by the continued

deposition and hatching of eggs. Hence, throughout July and August—the 2 months of active egg laying—the population shows a steady net increase until the maximum population is reached early in September. Thereafter, egg deposition having practically ceased, the decreasing trend in the population is no longer obscured. As the graphs show, the decrease continues as long as warm weather lasts in the autumn. When the weather becomes cold this decrease is arrested until early in May of the succeeding year. With the return of warm weather, the decrease is again clearly shown and becomes all the more striking as the temperature rises late in May and early in June. Probably the decrease in the population would be still more rapid with the occurrence of higher temperatures in midsummer, but any decrease at that time due to mortality cannot be distinguished from that resulting from the simultaneous emergence of adult beetles from the ground.

All reductions in population previous to the beginning of adult emergence must be a result of the various destructive agencies to which the insect is exposed in the ground in the course of its life cycle. In table 1 the population during the first half of June is indicated as averaging from 57 (7-year series) to 65 (4-year series) per cent of its maximum abundance the preceding September. It thus appears that a Japanese beetle population suffers a reduction from destructive agencies of from 35 to 43 per cent between the first part of September of one year and the middle of June of the succeeding year. Some of this destruction is doubtless caused by birds and other animals which feed upon the larvæ, but it is the view of the writer that by far the greater part is due to native soil-inhabiting microorganisms (pathogenic bacteria, fungi, protozoa, parasitic nematodes) originally infecting the immature stages of native *Scarabæidæ* and spreading thence to those of the introduced Japanese beetle.

Thus far there is no clear evidence that the introduced parasites of the Japanese beetle have played more than a minor rôle in bringing about the observed reductions in abundance of the insect. These reductions have been too general and wide spread to be attributable to the introduced parasites, which to date have been mostly confined to small areas in the immediate vicinity

of the points of liberation. However, the recent marked increase in their numbers at several of the stations where introductions have been made suggests that in the future these parasites are likely to play a far more important rôle in reducing Japanese beetle populations than they have up to this time. Although the outlook is as yet rather indefinite, developments in the parasite situation, although provokingly slow in reaching a decisive point, have in the past few years taken so promising a turn as to give good ground for optimism in the hope that the introduced parasites will furnish the key to the eventual control of the Japanese beetle. Realization of the potentialities in this direction, however, should not be permitted to blind one to the possibly indispensable, even if minor, rôle likely to be played by the less obtrusive organisms of native origin, which apparently have heretofore been mainly instrumental in effecting at least partial control of Japanese beetle populations.

#### COOPERATIVE SERIES OF SURVEYS

• Since the seasonal series of surveys were confined to the vicinity of the original point of entry of the Japanese beetle into this country, the question naturally arises whether conditions similar to those just described would hold in other portions of its range. Information on this point was supplied from a series of cooperative surveys conducted between 1932 and 1934 in various pastures distributed through a heavily infested portion of Salem County, N. J. This section is situated from 25 to 40 miles from the original center of spread of the insect and did not become generally infested until 1929.

These surveys differed from those of the seasonal series in that they were not always conducted in the same group of stations. Consequently, the conclusions drawn in regard to the seasonal changes in population are based upon a consideration of all the available evidence and not exclusively upon that from any uniform set of pastures.

Inasmuch as no surveys have ever been conducted in Salem County during that part of the summer when egg deposition is most actively in progress, no data were available for charting the course of population change previous to its reaching its maximum

abundance early in the autumn (fig. 2). The only surveys made at a time in the year when the population was close to a maximum was a series conducted in 9 pastures from September 20 to 22, 1933. These gave at that time a common average of 14.0 larvæ per square foot. A resurvey of the same pastures from October 6 to 11 of the same year showed a common average of 10.1 larvæ to the square foot, a decrease of 28 per cent (fig. 2).

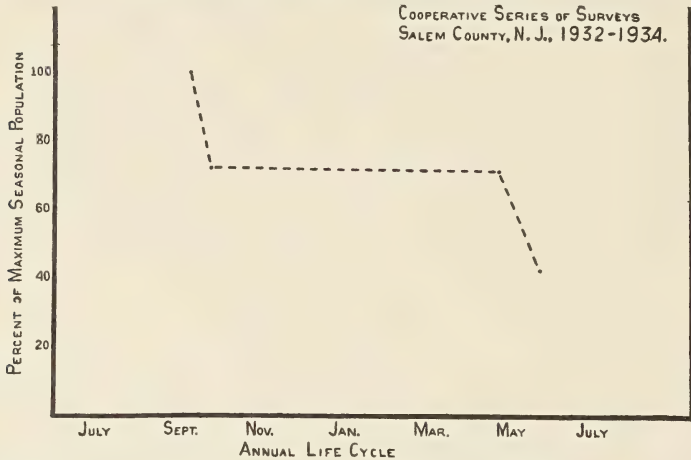


FIGURE 2.—Seasonal trends in relative abundance of Japanese beetle populations in the soil in percentages of the maximum average population in September, based upon records of the cooperative series of surveys for the period 1932-1934 in Salem County, N. J.

Records from a much larger number of pastures made it possible to compare populations found in Salem County during October with those occurring late in April and early in May of the succeeding year. A series of 20 pastures examined between October 18 and 28, 1932, and again between April 25 and May 4, 1933, yielded on the earlier occasion a common average of 11.5 and on the later one of 10.7 larvæ per square foot, a decrease of 7.0 per cent. Another series of 21 pastures (including most of those of the preceding group) examined October 2 to 11, 1933, and April 30 to May 11, 1934, gave for the earlier period a common average of 13.6 and for the later one of 14.6 larvæ per square foot, an increase of 7.4 per cent. The common average,  $+0.2$  per cent of the two sets of data thus accords fairly well with the evidences



of relatively insignificant winter decrease found in the seasonal series of surveys (*cf.* Figs. 1 and 2).

A comparison of the populations of pastures in Salem County early in May with the populations early in June is made possible by records from surveys made in 1933 and 1934. In the former year a series of 5 pastures, which about May 1 had yielded a common average of 22.1 larvæ per square foot, gave from June 5 to 8 an average of 10.5 larvæ and pupæ combined, a decrease in about 1 month of 52.5 per cent, while in 1934 a series of 4 pastures, which early in May had indicated a common average of 17.6, gave from June 4 to 6 an average of 12.4 larvæ per square foot, a decrease of 29.5 per cent. The average decrease from May to June for the 2 years was therefore 41.0 per cent (fig. 2).

By comparing these various results in relation to the maximum average population recorded in September, it is found that in October the decrease was 28 per cent, by the last of April or early in May the population remained essentially unchanged, while by the first part of June 57.5 per cent had been lost. Because they are based upon data from diverse sources, these figures can scarcely be regarded as more than very general approximations, but they show seasonal trends in Japanese beetle populations in the course of the annual life cycle that are in substantial accord with those indicated in the records of the seasonal series of surveys.

#### SUMMARY

Records of field surveys of the abundance of the soil-inhabiting population of the Japanese beetle conducted throughout the greater part of each year in a group of 8 stations, all situated within 12 miles of the original point of entry of the insect, and covering a total range of 7 consecutive years, reveal certain clearly defined trends in the course of its annual life cycle.

The general trends shown in Japanese beetle populations as regards relative abundance during the annual life cycle are consecutively as follows: (1) A rapid increase beginning late in June and extending through the summer, coincident with the season of active egg deposition, resulting in (2) the population reaching its maximum abundance early in September. This is followed by (3) a brief interval of rapid decrease lasting until

mid-October, (4) a long period of little or no apparent change extending through the winter and until about May 1 of the succeeding year, and (5) a second period of rapid decrease extending through May and into June, when adult emergence begins.

The absence of any significant winter reduction is attributed largely to the inhibitory effect of winter temperatures upon the activities of soil organisms parasitic or predatory upon the larvæ.

Rapid reductions in population are normally coincident with the occurrence of warm weather, and are therefore suggestive of biotic agencies as the cause. After June 15 the reduction is largely conditioned by the appearance of adults and their emergence from the ground, but previous to that date all reductions result from the various destructive agencies to which the immature stages of the insect are exposed in the soil, among which various native soil-dwelling organisms, parasitic or predatory upon the Japanese beetle, appear to play a major rôle, with birds and other surface-feeding animals playing a minor part.

Reductions in populations of the Japanese beetle due to its imported parasites have been too strictly local to figure as a significant factor in bringing about the general seasonal reductions recorded in this paper. More recent developments in the general parasite situation, however, hold much of promise as regards the eventual control of the Japanese beetle by the imported parasites.

The essential features in these changes in relative abundance of Japanese beetle populations throughout the annual cycle, which are primarily indicated in the records of continuous surveys in the older infested sections of the insect's range, are duplicated in the records of other surveys conducted in a more recently infested section in Salem County, N. J.

## PRINCIPLES OF SCIENTIFIC PUBLICATION

Scientific investigators may be grouped under the following categories: (1) The independent worker, *i.e.*, the individual who devotes a part or all of his time to investigation, carrying on his researches with his own financial resources. On the basis of motivation, this group of workers may be further differentiated as: (a) the investigator who does his work for what he can discover of saleable value, (b) the investigator who works because his problem bears a certain degree of fascination or interest, (c) the investigator who carries on because he is convinced that his investigation will benefit and advance the race (medical). (2) The salaried worker. This group also may be divided into: (a) the government, medical and museum investigator (with ideals of b and c, above), (b) the industrial investigator.

The person who is hired by the government, museums, or business is being paid to investigate. Nothing is said about publication. That is always an entirely separate matter. A business concern pays such an incumbent to carry on investigations, *not* to publish any findings. Museums usually maintain a Journal for publication of results, as also some research institutions, and the government. If a research hospital or institute wishes to become renowned through the high quality of its research it should be willing to pay for the publicity. The investigator who works to satisfy his curiosity or his desire for knowledge concerning a phenomenon of nature is under no more obligation to publish than is the man who discovers a new move in chess, or a new way of applying pigment to canvas—especially when he himself bears the expense of the investigation. Since when is a person under obligation to publish the fruits of his hobby? If Society wishes to benefit by the investigations of the men who voluntarily go through hours, days and months of drudgery and grind in order to discover a truth or principle of nature, Society should be willing to pay for the publication of his findings. After all, life, like marriage, should be a coöperative enterprise, and to expect or compel the investigator to shoulder the

burden of publication, in addition to the drudgery and cost of the investigation, is not only short-sighted but lacking in social sensibility and a sense of justice.

*Publication is not a part of research.* Research terminates when the investigator has discovered that for which he is seeking. If Society or the investigator's institution wishes, for reasons of its own, to know the result of any investigation, it should be willing to shoulder the burden of publication.

A recent article,<sup>1</sup> purporting to be a contribution on the publication problem, breaks down completely because its author fails to analyze his data, and because he fails to take more factors into consideration. In the fifth paragraph of that article, only the salaried investigator seems to be considered. The paragraph is not even clear as to who "rends the air with cries of anguish," the investigator or his institution. Certainly it should not be the worker. If the institution, what? Museums and government investigations are supported by the public. Is it the museum, or the public, or the government official which is rending the air? If the public hires research workers through museums, hospitals, or experiment stations to carry on investigations, should not the public pay for publication of the results? If the investigator is hired by an endowed research institution, that institution may publish or not as it sees fit (and they usually do). Why should it publish? Did the benefactor stipulate that the money should be used for publication? If Society desires the benefit of the investigations should it not be willing to pay for the publication?

There is no relation between research and publication, except in so far as Society desires the benefits of research. This applies especially to the independent investigator and independent research institutions. Society should be so organized that through endowments, the results of investigations may automatically be published. In fact Society should be so organized as to be able to adequately hire all capable investigators.

This brings us to the old question of what constitutes publication. There has been a tendency in recent years to shirk responsibility of publishing so-called "raw data."

*All data should be published.* One of the fundamental characteristics of scientific work is that it is so conducted that it may

<sup>1</sup> Science, 84: 310-311, October 3, 1936.



be repeated or checked up—gone over by others as often as necessary and with whatever variations may be deemed advisable. This presupposes publication of all data and methods. Data unpublished is data lost. The structure built on this lost data is a structure without visible or substantial foundations. The next architect is unable to examine the foundations of the edifice. He must then go through the arduous and time consuming process of accumulating another set of data in order to check up on the stability of the superstructure. The suppression of raw data hampers discussion and criticism, one of the fundamental characteristics of science. I can well perceive how delighted pseudo-scientists would be to place their "discoveries" beyond the pale of criticism and discussion by the suspension of their raw data.

The filing of "raw data" in the institution's morgue is unsatisfactory to any worker separated by an ocean or even a continent. It will cost him as much to go to the data as it would cost to have the data published. To have the data sent him will entail risk of loss. The same expense and hazard is repeated with the second, the third, and other reviewers or checkers. Inevitable wars jeopardize such filed data. So does a change in department head, or future shortage of space. We have recently witnessed the junking of years of accumulated material by a new museum president who did not fancy a certain line of investigation. Publication makes data virtually indestructible and makes it available on all continents and in all culture centers. It is the obligation of organized Society to make such data available to its underpaid investigators in all countries. In the long run, it is more economical to pay for such publication. Society's obligation is to endow scientific publications, as well as museums, hospitals, university buildings, bell towers, and dog cemeteries.

ARTHUR PAUL JACOT

*The Microscope.* By Simon Henry Gage, Emeritus Professor of Histology and Embryology in Cornell University. 16th Ed. rev. and enlarged, 617 pp., illus., bibliog., Ithaca, N. Y., Comstock Pub. Co., 1936. \$4.00.

Since the 15th edition (1932) of this work was reviewed in the JOURNAL of the New York Entomological Society (40: 389-390), it seems fitting that notice also should be given herein of this newly issued 16th edition. Most gratifying advances are being made every year in microscopical knowledge so it is desirable to add, from time to time, a portion at least of the outstanding improvements in successive editions of this work. In this edition, therefore, have been added the simplified means of reflecting ultra-violet radiation by mirrors coated with aluminum by the vapor method, which promises much for the future of optics and astronomy. There has been included also a chapter on micro-incineration with its possibilities for giving definite information concerning the presence, amount and location of the fixed mineral salts in the tissues and cells of the body.

All the well known features of previous editions which have proved of widest usefulness have been retained and where necessary have been amplified. These include treatment of such topics as lighting, natural and artificial; dark field microscopy and its application; micro and pocket spectroscope; interpretation of appearances; magnification and micrometry; drawing with the microscope and with projection apparatus; photographing and enlargements; cabinets, slip and cover glasses; mounting, labeling and storing microscopical preparations; fixing and preservation of tissues, organs and organisms; infiltrating, imbedding, sectioning, and staining and mounting for the microscope. There are also given a brief history of lenses and microscopes and a comprehensive bibliography of the entire subject.

J. S. W.

## A NEW "SILVER-MARKED" EUCOSMA (LEPIDOPTERA—OLETHREUTINÆ)

BY WM. T. M. FORBES

CORNELL UNIVERSITY, ITHACA, N. Y.

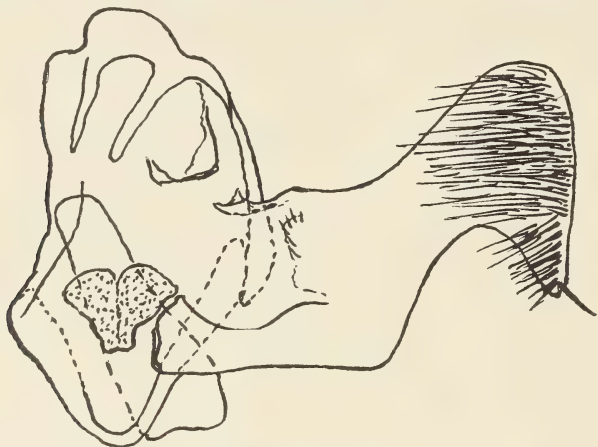
It has reached the point when new species of Lepidoptera outside of a few critical groups are beginning to be rare from New York. The following is the most striking that has been through my hands for some time, and has no very close relative in the eastern states. The capture of seven specimens in two seasons gives hope that it may turn out fairly common.

### *Eucosma lathamii*, new species

General structures of typical *Eucosma*; fore wing with  $M_3$  and  $Cu_1$  closely approximate at margin, and  $M_2$  somewhat; apex produced and outer margin oblique and somewhat concave; hind wing with  $M_3$  and  $Cu_1$  rather long-stalked.

Pure white (not really silvery) and fuscous brown. Head and thorax white (unlike the other silver marked species from the east, but like *morrisoni* and *bolanderana*), the outer  $\frac{2}{3}$  of antennæ, outer side of palpi, tips of tegulæ and abdomen tinted with pale gray-brown. Anal tuft pure white. Fore wing brown, marked with pure white;—a white costal stripe, in the male starting below the brown costal fold, narrower just before middle, then widened and containing brown pm. and st. dots and tapering to a point at apex; in female running along costal edge toward base, with a brown subcostal stripe and another white stripe below that representing the base of the male costal stripe, but cut off from its outer portion. Median stripe in male forking off from the costal one at  $\frac{1}{3}$ , in female continuous with the second stripe at base, but leaving the part corresponding to the costal stripe of male as a short subcostal spur,—then in both sexes of almost even width to middle of outer margin; cut by an oblique spot or bar at lower angle of cell; three white stripes below this, the first lying on the anal convexity, and extending from just beyond base to  $\frac{2}{3}$ , the second along inner margin from  $\frac{2}{3}$  to  $\frac{4}{5}$  and the third along basal lobe of inner margin. The first two of these stripes connect in male to form an offset stripe, and the one female has an additional small spot beyond the tip of the first, cut off from the median stripe by the brown fold only. Base of fringe powdery gray, outer  $\frac{2}{3}$  light fuscous, like hind wing. Hind wing light fuscous, the base of fringe hardly paler, but outer  $\frac{2}{3}$  whitish. 16 mm.

This species is closest to *E. morrisoni*, as shown by the stripe of dark ground below the median stripe centering on the fold, the powdery fringe and the anal spine on the genitalia (see fig-



*Eucosma lathamii*

ure); but is distinct in the dark brown ground and many details. The genitalia are about as in *morrisoni*, but the terminal edge of the valve is straighter. In Heinrich's key (Bull. U. S. Nat. Mus. 123: 74) the species will run to alternative 30, but differs in the white head and thorax, and deeper duller brown ground; in mine (Lep. N. Y. 417) it runs to alternative 5, and separates in the same way.

Orient, Long Id., New York. Holotype June 18, 1935, paratypes June 8, 10, July 11, Aug. 8, 12. The types will be divided between the U. S. National Museum, Cornell University and Mr. Latham's collection. The larva is certainly a borer, and is to be expected in Compositæ.



## A CYPHOPHTHALMID FROM SOUTH AMERICA. (ARACHNIDA, PHALANGIDA)

BY NORMAN W. DAVIS

This is the third species of the suborder to be found in the Western Hemisphere and the first from South America. The material was received by Dr. Arthur Jacot in collections from August E. Miller. Dr. Jacot very kindly turned this material over to me.

Unfortunately the vial containing these specimens was labeled only "Kartabo, Bartica District, British Guiana." No additional data have been obtained. In view of the scarcity of these animals it was decided to publish in spite of the deficiency.

### Siro kartabo new species

MALE. Length 2.8 mm.

Lengths of segments of appendages in millimeters:

Chelicera, I 1, II 1.4, III .24, total length 2.6.

	tro- chanter	femur	patella	tibia	meta- tarsus	tarsus	claw	total
Palpus .....	.42	.49	.32	.42		.39	.06	2.10
Leg I .....	.35	.91	.56	.70	.42	.70	?	?
Leg II .....	.32	.81	.42	.56	.35	.56	.14	3.16
Leg III .....	.28	.70	.35	.42	.28	.53	.18	2.74
Leg IV .....	.35	.81	.46	.56	.42	.56	.18	3.34

Dorsum with anterior median protrusion formed by two nearly vertical plates connected dorsally by a transverse ridge. Dorsum otherwise rounded anteriorly.

Eyes lacking. Stink-gland tubercles approximately as high as their basal diameter, tapering distally, and set at a distance very slightly less than their basal diameter from the lateral margin of the carapace. Apical nodules of stink-gland tubercles large and prominent. Posterior thoracic suture present arching caudally across the carapace from between the third and fourth coxæ.

Maxillary lobe of coxa I extending about one-third of the total length of the coxa. A short row of hairs beside this lobe. Maxillary lobe of coxa II very large, broader than long, deeply constricted caudally. Apparently coxæ

I and II are movable and coxæ III and IV are fixed. Coxa IV wider than coxa I; coxa I wider than coxa III; coxa III slightly wider than coxa II.

Genital opening elliptical, nearly circular, unarmed. Each spiracle enclosed on the inner and caudal sides by the lateral suture.

Eighth and ninth sternites and ninth tergite fused into a single plate which surrounds the anal operculum. This plate with small lateral indentations in the anterior margin. Anal operculum with slight lateral depressions.

First segment of chelicera laterally compressed. Dorsal and lateral surfaces rounded, mesal and ventral surfaces flattened. Dorsal surface as seen from side with a deep depression into which fits the anterior-median protrusion of the carapace. Just anterior to this a prominent retrorse pointed eminence which appears as a transverse ridge in dorsal view. Anterior to this ridge the dorsal margin curves slightly dorsad and is armed with several small hairs and a few minute tubercles. Ventral margin as seen from the lateral side constricted near base then abruptly expanded forming a conical eminence, anterior to this the surface is slightly concave and armed with scattered small hairs and minute tubercles. Second segment tapered distally to a point just proxad of the chelate portion and then expanded slightly, roughly circular in cross-section, chelate portion armed with three denticles. Third segment slender, unarmed, circular in cross-section.

Trochanter of palpus curved dorsally, incrassate distally, armed with a very few hairs ventrally. Femur straight, cylindrical, armed with a few hairs. Patella curved slightly ventrad proximally, expanded distally. Tibia nearly straight. Tarsus fusiform, straight, terminating in a short straight claw.

Legs granulated and garnished with a few hairs which are more numerous on tarsi than on other segments. Claw of leg I smooth. Claw of leg II armed on ventral side with a row of five or six small close-set denticles and on the posterior side with two tubercles. Claw of leg III armed on the anterior side with two tubercles and on the posterior side with two tubercles. Claw of leg IV strongly curved, armed with two tubercles on the anterior side and two tubercles on the posterior side. Dorsal eminence of tarsus IV consists of a rounded basal part from which a group of small bristles projects.

Body dark reddish brown. Appendages slightly lighter in color.

FEMALE. Similar to male but differing in the following respects: metatarsus IV and tarsus IV much smaller in diameter than those of male; dorsal eminence lacking on tarsus IV.

Holotype male, allotype female, paratype male. Kartabo, Bartica District, British Guiana. Cornell University collection.

*A Manual of Entomological Equipment and Methods. Part II.*

By Alvah Peterson. John S. Swift Co., Inc., St. Louis, Chicago, New York, Indianapolis. 334 p. inc. 21 pl. 1937. \$4.50 plus postage.

It is a pleasure to record the publication of Part II of Dr. Peterson's "Manual of Entomological Equipment and Methods." The first part was reviewed in the March, 1935 issue of this JOURNAL. The second part presents abstracts and original contributions on rearing information, together with abstracts of papers dealing with the transportation of living and pinned insects, the marking, and collecting of insects, insect photography, sampling, mounting, trapping, inflating, staining, museum and laboratory methods, etc., all highly useful and important to all kinds of entomologists and exceedingly convenient to have between two covers.

Approximately 1125 abstracts are arranged alphabetically by authors; ten plates illustrate cages for rearing insects, parasites, wood borers, for oviposition studies, etc.; seven plates deal with feeding, counting, collecting, and with museum equipment, and four plates with transportation, liberation and miscellaneous equipment. Adequate indexes make it easy to locate special interests. Dr. Peterson's book is a planographed production, in a substantial blue cloth binding, with gold lettering. Its text touches every phase of entomology, and it is a much needed work. It is hoped that it will be adequately supported so that its author will be encouraged to issue supplements when necessary.

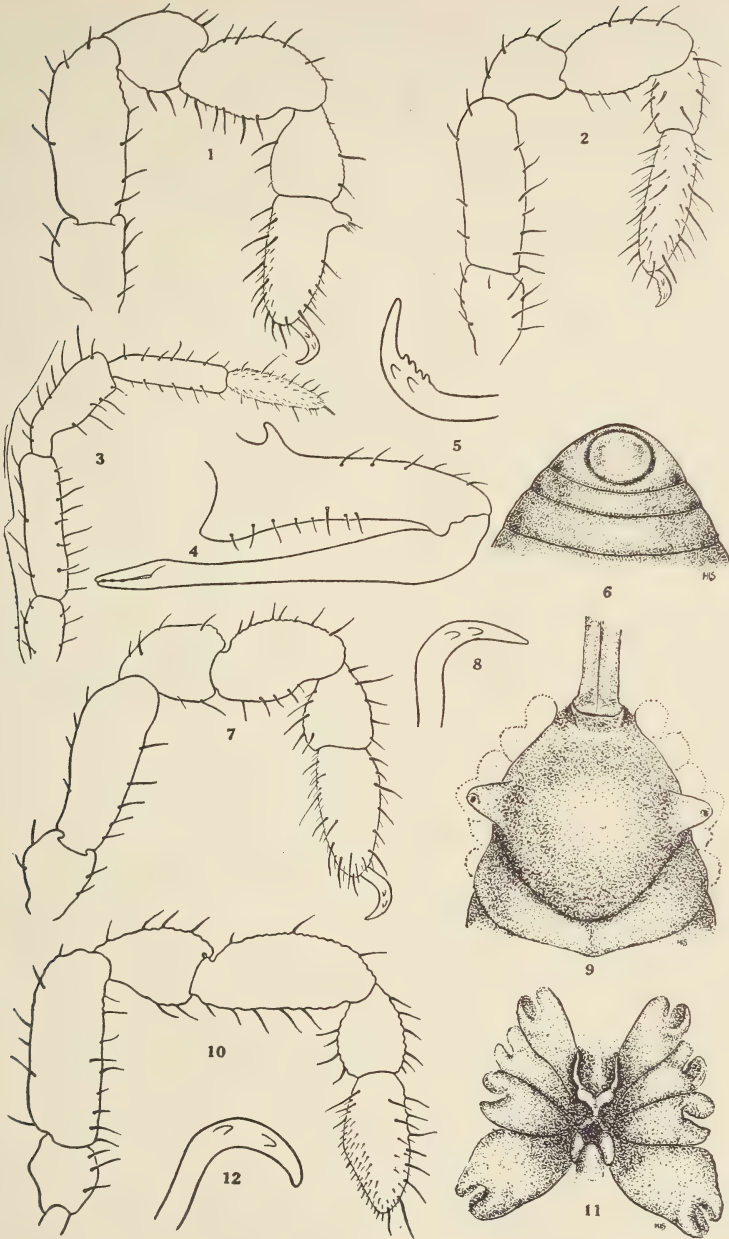
H. B. W.

## PLATE I

*Siro kartabo*, male

- Figure 1. Fourth leg, right.
- Figure 2. Second leg, right.
- Figure 3. Palpus, right.
- Figure 4. Chelicera, right.
- Figure 5. Second tarsal claw.
- Figure 6. Anal operculum and posterior sternites.
- Figure 7. Third leg, right.
- Figure 8. Fourth tarsal claw.
- Figure 9. Cephalothorax, dorsal view.
- Figure 10. First leg, right.
- Figure 11. Cephalothorax, ventral view.
- Figure 12. Third tarsal claw.





SIRO KARTABO

*General Entomology.* By Robert A. Wardle, professor of Zoölogy, University of Manitoba, Winnipeg, Canada. 8vo., washable cloth, 311 pp., 96 illus. Philadelphia, P. Blakiston's Son and Company, 1936. \$2.25.

This is not "just another book," since it proves to be a work that is well worthy of the attention of the working entomologist because the author has emphasized a broad appreciation of the basic principles of the subject. Beginning with such matters as external and internal anatomy, development and life cycle, the discussion continues into physiology and behavior, and later into Proturoid and Palaeopteroid, Orthopteroid and Plecopteroid, Zygopteroid and Ephemeropteroid insects. These are followed by similar treatment of Hemipteroid, Panorpoid, Coleopteroid, and Hymenopteroid insects. Though not elementary in character, the book is intended for the use of the general student of entomology rather than the specialist who would require detailed knowledge of such ramifications as insect morphology, insect classification and the like. A considerable number of illustrations in proportion to the size of the book have been included; some have been borrowed from other works, with suitable adaptations, and many have been specially prepared for this work. Use also has been freely made of subject material and illustration from pioneer workers, as well as such from recent monographic studies. Living specialists in various fields of activity have been designated by name and in numerous instances résumés of important work by them have been included. This feature alone is certain to add much to the general usefulness of the book, particularly to entomological workers isolated in locations remote from centers of contact with professional colleagues. J. S. W.

## AN OLIGONEURID FROM NORTH AMERICA\*

BY HERMAN T. SPIETH

COLLEGE OF THE CITY OF NEW YORK

Despite the many serious and wholly justifiable objections to describing a single specimen, I am following such a procedure for these reasons: (1) The specimen under consideration is obviously a member of an exotic family about which our information is meager, and this is the first record of the family from North America; (2) the collecting methods employed give a clue as to why the nymphs of this species have not been taken previously.

The specimen is an almost mature male nymph and was collected from the White River at Decker, Indiana, on July 27, 1932, by Stacey Denham, who kindly forwarded it to me. Its description is as follows:

Length, including tails, 12.5 mm.; exclusive of tails, 10 mm. Head roughly semi-globose with the mouth parts projecting posterioro-ventrally; compound eyes huge, occupying most of the area of the head, and contiguous along the mid-line, thus completely eliminating vertex except for a small area anteriorly. Nymphal eyes undivided; those of the adult as seen through the thin chitin show no indication of being divided. Lateral ocelli wedged between the antennæ and compound eyes, being displaced so that they are anterior and ventral to the median ocellus which lies in an angle formed by anterior margins of eyes. Fronto-clypeal area greatly reduced; along edge of this area and the ventral edge of the parietal areas a fairly dense fringe of short setæ. Antennæ twelve-jointed, short and stubby; scape short and heavy; pedicel almost as heavy and much longer, comprising a third of the total length of the antennæ; remaining segments subequal and gradually decreasing in diameter toward the tip.

Mouth parts typically oligoneurid; labrum (Fig. 10) uniformly pilose over the anterior surface; mandibles (Fig. 5) with a large, well developed molar area, and reduced, smallish incisors,

\* The author takes this opportunity to express his appreciation to Mr. Stacey Denham for the specimen considered in this paper, and to the American Museum of Natural History and especially Dr. F. E. Lutz for providing space in which to conduct research.

the outer one having three small teeth at tip and the inner one appearing like a huge, sharp-pointed seta; the lacina mobilis as long as outer incisor; maxillæ (Fig. 1) with semi-lanceolate galea-lacinia; palps two-jointed; basal segment short and the distal one long, large, curved and finger-like; at the base of maxillæ a large tuft of respiratory filaments as in *Isonychia*; labium (Fig. 4) heavily pilose; glossæ small and lying dorsal to the larger paraglossæ; palps two-jointed, the second large and broadly expanded.

Thorax short and compact; the anterior and posterior margins of the pronotum straight and parallel. An extension of the posterior-lateral area of the pronotum extending as a broad lobe-like projection posterior to the prothoracic leg (Fig. 9). Wing pads large, thick, and blackish as in all nymphs just before emergence; the metathoracic wings of the adult apparently good-sized.

Legs (Figs. 7, 8, 9) peculiar in that the coxæ and trochanters of the meso- and metathoracic legs are very long and robust. Coxa of fore-leg about three-fourths as long as femur; trochanter small; tibia forming a flat blade-like structure about one and one-half times the length of femur and ending in a blunt semi-hook, on the outer side of which is a small unsegmented papilla-like structure which represents the tarsus; inner side of basal half of femur and middle three-fourths of tibia bearing extremely long slender setæ which are secondarily dissected; a patch of long slender setæ on inner surface of coxa; outer surface of coxa, trochanter and femur sparsely setose. Coxa of second leg subequal to femur, longer than any other part and covered with setæ on outer surface; trochanter robust and longer than tibia or tarsus, and expanded and rounded on medio-ventral surface, this surface being covered with long robust setæ; femur covered with robust setæ; tarsus subequal to tibia and both sparsely covered with short setæ; tarsus ending in a single slender claw. Coxa of hind leg heavy and long, representing one-third of entire length of leg, and fairly densely covered by long slender setæ; short, semi-globose trochanter covered with long slender setæ on ventral surface; femur, tibia, and tarsus, which decrease in length and robustness in order named, clothed with long, heavy setæ; tarsus tipped by long slender claw. Adult



legs as seen through the nymphal chitin appearing very slender and weak.

Abdomen long, slender, and cylindrical; segments gradually increasing in length and decreasing in diameter from first to ninth inclusive; tenth segment considerably smaller than any other; tergites uniformly covered with short, stubby setæ; on anterior sternites setæ much denser, longer, and finer than on corresponding tergites, with a gradual reduction in density and length of setæ on more posterior sternites until ninth sternite matches ninth tergite; in addition a distinct fringe on posterior edge of all sternites due to increased density and length of setæ. Through the thin nymphal chitin, it can be seen that the adult would have a broad dark, irregular band on its posterior edge of each abdominal tergite increasing in width posteriorly until that of the ninth segment would occupy almost half of the tergite; no indications of postero-lateral spines on segments 1 to 7 inclusive; lateral spines on segments 8 and 9 short, not extending beyond posterior margin of their respective segments.

Gills present on abdominal segments 1 to 7 inclusive; last six (Figs. 2, 3) consist of single, slender, flat, plate-like structures which extend postero-laterally from posterior angle of each segment, apparently none having any tracheæ; first gill (Fig. 11) a huge, highly dissected plate-like structure that has migrated and rotated so that it extends ventrally and parallel to the longitudinal axis of the body and lies between the posterior pair of legs. It is completely invisible from a dorsal view and when first seen seems to arise from the thorax; also there is a median, finger-like, posteriorly directed process from posterior edge of first sternite.

Nymphal genital apparatus appearing as a truncate cone with a concave top surface. It is impossible to determine what the adult genitalia would be like. Three subequal caudal tails; lateral ones having a dense fringe of long, slender setæ on inner side and a similar fringe on both sides of middle tail; laterals with 25 segments, the middle tail 22.

It is possible from the structure of the nymph to determine something about its ecology. The long, slender, cylindrical shape eliminates the possibility of its living under stones, etc., as *Hep-*

*tagenia* and its relatives do. The lack of digging apparatus indicates it is not a burrower. The immaculate condition of the specimen shows it not to be a sprawler like *Canis*, or a clamberer like certain *Ephemerella*, and the peculiar build of the gills, especially the huge first gill, eliminates the chance of its being a swimmer amongst the vegetation such as *Callibætis* and to some extent *Siphonurus*. Superficially the specimen looks like *Isonychia*. Inspection of the first leg and mouth parts confirms the notion that this species probably lives and feeds much like *Isonychia*, i.e., it lives on the bottom in a place where the current is fairly rapid and, by facing the current, it is able to sift out its food with the long setæ that are found on the front legs. There are, however, certain obvious and striking differences between *Isonychia* and this specimen: (1) In the relative proportion of the various parts of the legs, as well as their disposition in relation to the rest of the body; (2) in the arrangement of the gills: in *Isonychia* all seven pairs are quite similar in structure and location, while in this species the task of respiration is taken over mainly by the first pair which is carefully protected between the metathoracic legs. It is necessary to consider these structures further in order to comprehend how the nymph lives.

The coxæ all extend directly downwards and the fore-coxæ are less than half the length of the meso- and metacoxæ. The fore-leg (Fig. 9) is held somewhat like the arm of a boxer when he fends off a blow that is directed toward his face. From the mesocoxæ the trochanter and femur extend outward and upward while the tibia and tarsi continue outward and downward so that the rounded setose inner surface of the trochanter and the end of the tarsus are all that come in contact with the substratum. From the metacoxæ the remainder of the leg extends at a right angle straight backwards and parallel to the longitudinal axis of the body so that the anterior surfaces of the trochanter, femur, tibia and tarsus come into contact with the substratum. Thus the body of the nymph and also the first pair of gills which are located ventrally are held away from the substratum by the long meso- and metacoxæ, while the outwardly extended mesothoracic legs keep the specimen from rolling sidewise and the posteriorly directed metathoracic legs keep the nymph on a level keel facing

into the current. Since the fore-coxæ are short, the fore-leg moves freely in the area between the substratum and the body, and the long hairs filter the water, thus insuring food for the nymph and simultaneously insuring filtered water for the first gill. This condition, plus the fact that the main part of respiration has been taken over by this protected gill, indicates that the nymph lives in an environment where there are a great many small particles in suspension. This is in accord with the statement of Mr. Denham that the substratum upon which this specimen lived was sandy. When we know more about this species, I think we will find that the nymph lives in sandy streams, probably at the riffle end of sand bars.

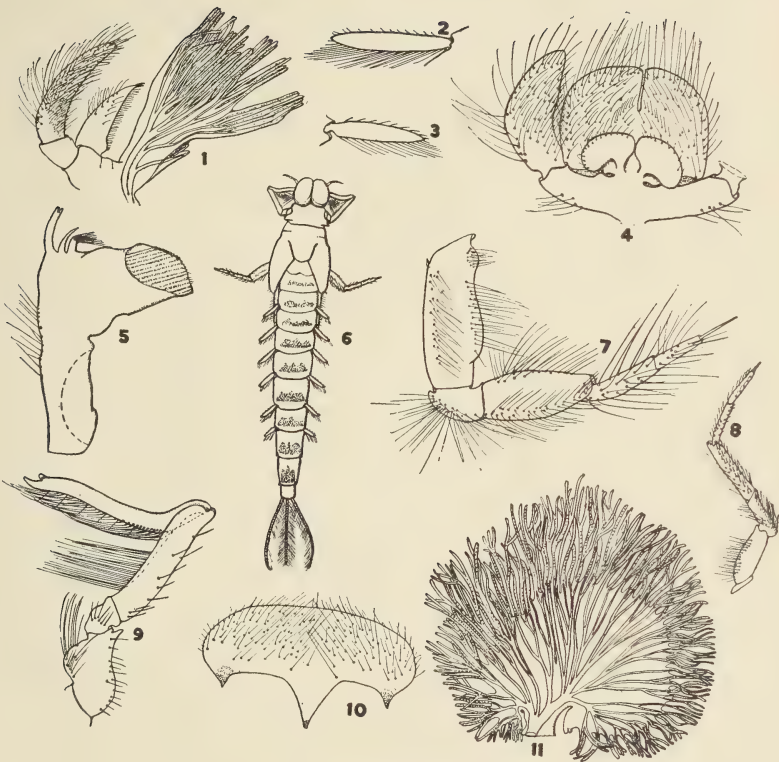
Phylogenetically the nymph shows no relation to *Isonychia*. A comparison of the general shape, gills, legs—especially the first leg—, and mouth parts with those of the nymph of *Oligoneuriella*, *Elassoneuria*, and *Noya* indicates without a doubt that it is a member of the family Oligoneuridæ. The type of this family is *Oligoneuria anomala* from Brazil, the nymph of which is unknown. Very closely related is *Oligoneuriella rhenana* of Europe. The nymph of *O. rhenana*, which is well known, shows a decided resemblance to the specimen described above. There is, however, in Central America the genus *Homeoneuria* which is also known from adult specimens only. In view of these facts, I am refraining from giving this specimen any name. The close similarity of the nymph to that of *Oligoneuriella* indicates that it may be a member of the genus *Oligoneuria*, since the adults of these two genera are closely related.

Why has this species never been collected before? The method of capture gives a clue. The specimen was taken from the deeper waters of a sandy river by means of a Peterson dredge. Most collections of mayfly nymphs are made in small streams, ponds, etc., and along the edges of larger bodies such as lakes and rivers. Those species that are peculiar to the deeper waters of lakes and especially of rivers are still poorly known. The adult of this species probably emerges, mates, deposits its eggs, and dies all in a single night. This is somewhat confirmed by the fact that the adult legs would probably be very weak, if not almost functionless as is the case with *Campsurus* and *Ephoron*. Unlike these, however, the adult of this specimen is probably negatively phototropic.

## PLATE II

- Figure 1. Right maxilla.  $\times 64$ .  
Figure 2. Second gill.  $\times 60$ .  
Figure 3. Seventh gill.  $\times 60$ .  
Figure 4. Labium.  $\times 64$ .  
Figure 5. Right mandible.  $\times 130$ .  
Figure 6. Dorsal view of nymph.  $\times 12$ .  
Figure 7. Metathoracic leg.  $\times 50$ .  
Figure 8. Mesothoracic leg.  $\times 21$ .  
Figure 9. Prothoracic leg.  $\times 50$ .  
Figure 10. Labrum.  $\times 130$ .  
Figure 11. First gill.  $\times 21$ .





OLIGONEURIDÆ

## BOOK REVIEWS

*Forest Insects: A Textbook for the Use of Students in Forest Schools, Colleges, and Universities, and for Forest Workers.*  
By R. W. Doane, Professor of Biology, Stanford University;  
E. C. VanDyke, Professor of Entomolgy, University of California;  
W. J. Chamberlin, Professor of Forest Entomology, Oregon State College, and H. E. Burke, formerly Senior Entomologist, U. S. Department of Agriculture. First ed., 8vo., cloth, 463 pp., 234 illus. N. Y. McGraw-Hill Book Co., 1936. \$4.50.

The comments on this book which follow are made from the viewpoint of a student of Coleoptera, not of a specialist in forest entomology. Since 217 of the 463 pages of the volume are devoted to consideration of insects of that order, the work will have a special appeal to all who may be concerned with their study. The various topics treated include such as life history and control of bark beetles, ambrosia beetles, and flathead and roundhead borers, with discussion in some detail of surveys of infested areas, analysis of such surveys, conditions necessary to successful control, preventive methods, treatment after attack, character of host plants, and the like. Considerable attention has been given to such matters as insect distribution and classification, as well as to the study of various ecological factors bearing on species attacking coniferous twig, cone, and broadleaf trees. Due consideration also has been given to control of other beetles attacking forest trees, notably, such as predaceous ground beetles, rove beetles, lady beetles, cylindrical bark beetles, cucujids, skin beetles, steel or hisster beetles, sap-feeding beetles, ostomids, snapping or click beetles, cross-wood borers, fireflies and soldier beetles, checkered beetles, powder post beetles, ptnids, death watch beetles, bostrichids, true powder beetles, darkling beetles, melandryids, pythids, oedermerids, mordellids, pyrochroids, blister beetles, May beetles, stag beetles, leaf eating beetles, flea beetles, tortoise beetles, and various weevils.

The book as a whole has been so prepared that it will be useful in the field as well as in the laboratory and classroom, and there

are also chapters on forest tree pests in other orders of insects, notably the moths and butterflies, sawflies, horn tails, bees, ants, aphids, scale insects, termites, and others. Lists of the more important forest trees and their principal insect enemies are included, and control methods for each order of insects are given. The subject matter purposely has been couched in non-technical language so as to be of wider usefulness to the forest ranger and the beginner in forestry, while the very full bibliographies at the end of each chapter will be particularly helpful to special students who may wish to make a more detailed survey of various insect groups.

J. S. W.

THE ELUSIVE JOHN THORLEY, AUTHOR OF  
"MELISSELOGIA, OR THE FEMALE  
MONARCHY"

One hundred and thirty-five years after the publication at Oxford of Charles Butler's first edition of "The Feminine Monarchie, or The Histori of Bees," there appeared "Melisselogia, or the Female Monarchy, Being an Enquiry into the Nature, Order and Government of Bees, . . ." by the Reverend Mr. John Thorley, of Oxon. Mr. Thorley's book was printed in London, 1744, "for the author" and sold by N. Thorley, probably a relative, and by J. Davidson.

Like Butler, Thorley was a minister, as well as a beekeeper, but Thorley's book, although practical and correct for his time, is not now so quaint and amusing as Butler's "Feminine Monarchie" which reached a third edition and included such mythical accounts as bees building an altar in a hive, around a consecrated host.

Thorley had 459 subscribers for his book, including 43 ministers, and as many of them subscribed for several copies, and one for 100, the total number of subscriptions amounted to 784.

Almost nothing seems to be on record concerning Thorley's life. He lived at Chipping Norton, in the County of Oxford, when he published his book, and by 1743 he had behind him forty years of experience as a practical beekeeper. He was married, because on page 164 of his book he mentions his little daughter. He also had a maidservant and he was opposed to drinking and did not describe the making of mead and metheglin, as did Butler, 135 years previously. As would be expected, in view of his calling, his book is interspersed with references to divine wisdom, and because of his praise of King George and of the fact that he utilized every opportunity to urge "Britons and Hibernians" to be loyal, we may conclude that he was a faithful subject of the king.

According to the Bodleian Library, although he is described as "of Oxford," he was not a member of the University and did not hold a living or curacy in any Oxford church. In addition, the City Librarian of Oxford was unable to trace any biographical particulars about him. And so for the present at least, apart from his authorship of Melisselogia, details of his life are still missing.

H. B. W.



# The New York Entomological Society

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

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JUNE, 1937

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### INSECT DEVELOPMENT ANALYZED BY EXPERIMENTAL METHODS: A REVIEW

#### PART II. LARVAL AND PUPAL STAGES<sup>1</sup>

BY A. GLENN RICHARDS, JR.

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<sup>1</sup> This paper was prepared in the biological laboratories of the University of Rochester and Cornell University.

JUL 1 1937

## I. INTRODUCTION

Following the recent physiological reviews of Wigglesworth (1934a) and Hoskins & Craig (1935) it may seem surprising that another should be written so soon. This paper is an attempt to supplement these reviews by analyzing data from the point of view of the embryologist. Most of the subjects discussed are mentioned only briefly or even not at all in these other reviews; some subjects, of necessity, are treated again but from the embryologist's viewpoint rather than that of physiology *sensu strictu*. The origin of the germ cells and the differentiation of the gut have already been treated in Part I. Nutrition and metabolism are covered by Uvarov (1928), Needham (1929), Wigglesworth (1934a) and Hoskins & Craig (1935); effect of climatic factors by Uvarov (1931) and Imms (1932); heterogony and growth-gradients by Huxley (1932); wing-production and physiological races by Hoskins & Craig (1935); and the developmental aspects of genes by Goldschmidt (1932), Cohen-Kysper (1933), Morgan (1934) and Zawadowsky (1935). None of these topics will be repeated here.

This paper attempts to analyze from the embryologist's viewpoint the rôle of hormones in development, the possibility of a differentiation center in later insect development similar to that demonstrated in the early stages of ontogeny, the available data on organ development after the segregation of their presumptive anlagen, the voluminous data on insect regeneration, the possibility of organ development and regeneration representing gradient-field phenomena, and, finally, the phenomenon of diapause or cellular-dormancy.

The diverse appearances of the development of different insects has led to several attempts to correlate the facts of insect metamorphosis. The hypothesis here accepted as most satisfactory was proposed by Berlese in 1913 and is comprehensively treated by Imms (1931). According to the classification based on this hypothesis, post-gastrulation development of insects may be divided into three periods: (1) The *protopod* stage at which the embryo is incompletely differentiated as a whole both internally and externally. The head and thorax are segmented and bear rudimentary appendages but the abdomen lacks appendages

and is poorly or not at all segmented. (2) The *polypod* stage in which the abdomen has become completely segmented, each segment bearing rudimentary appendages, the tracheal invaginations have begun and the internal organs are well defined. And (3) the *oligopod* stage in which final differentiation takes place, the cephalic and thoracic appendages attain their definitive form, the tracheal system becomes completed and the abdominal appendages resorbed except such as are to be retained by the adult (cerci and genitalia). These three stages can be recognized with varying degrees of distinctness in the various insect groups but the point of interest is that *they are not all invariably passed within the egg*.

According to this hypothesis the hemimetabolous insects pass through all three stages within the egg and emerge in a post-oligopod stage termed a nymph, whereas the holometabolous insects emerge at an earlier stage, sometimes in the protopod stage as veritable embryos (*e.g.* primary larvæ of endoparasitic Hymenoptera), sometimes in the polypod stage (*e.g.* lepidopterous caterpillars), sometimes in the oligopod stage (*e.g.* campodeiform larvæ of Coleoptera and Neuroptera), and sometimes in a degenerate oligopod stage which is apodous (*e.g.* dipterous larvæ). In the Hemimetabola, then, the nymphal instars are preparatory to the development of the adult, but in the Holometabola the larval instars are preparatory to the development of the pupal instar which is the ontogenetic counterpart of the nymphal instars of the Hemimetabola.

Although Berlese's three hypothetical embryonic stages seemingly rest on an environmental or rather nutritional basis for time of emergence from the egg, and so only indirectly affect the topic of this paper, they illustrate the undesirability and practical impossibility of satisfactorily separating development within the egg from development after emergence from the egg. Indeed, most of the experimental work which has produced satisfactory results has dealt with the pre-protopod stages within the egg, and the polypod and oligopod stages after emergence from the egg. From the developmental viewpoint this represents a continuous physiological process.

## II. EXPERIMENTAL MATERIALS AND METHODS

The forms experimented upon include representatives of all the major orders and several of the minor orders. The majority of the papers cited are based on amputation and transplantation and the modification of environmental factors; genetic analyses and constrictions are next in importance. Comparison with the techniques used on embryos (Part I) shows a marked difference in the relative values of the various methods, partly due to the lack of any satisfactory technique for the transplantation of egg-parts. [References in italics give methods in detail.]

1. **Amputation and transplantation** of body components to determine the effect on (a) the donor, (b) the host, and (c) the graft [Meisenheimer 1908 ff., *Kopeć* 1918 ff., Bodenstein 1930 ff., Caspari 1933, *Wigglesworth* 1934c, *Ephrussi & Beadle* 1937 and numerous other workers on various insects].

2. **Constriction** of larvæ and pupæ [Urech 1897, *Hacklow* 1931 and Caspari & Plagge 1935 (Lepidoptera), and *Fraenkel* 1935 (*Calliphora*, a fly)].

3. **Injection of blood** of one stage or sex into another [*Kopeć* 1911, Umeya 1926 and Buddenbrock 1930b (moths), and *Fraenkel* 1935 (*Calliphora*)].

4. **Formation of parabiotic twins** by (a) grafting together pupæ and pupal parts [*Crampton* 1899 (Lepidoptera)]; (b) grafting together nymphs [*Wigglesworth* 1934c (*Rhodnius*, a bug)].

5. **Tissue culture** [Lewis 1916 (grasshopper testes); *Goldschmidt* 1917 (moth testes); *Frew* 1928 (imaginal discs of *Calliphora*), and Charin 1930 (malpighian tubules of cockroaches and wing-anlagen of lepidopterous pupæ)].

6. **Puncturing** (a) the chitin to produce scars to mark selected points during development, these scars being passively transmitted to the underlying new cuticle through several instars [*Lew* 1934 (dragonfly eye)]; (b) the wing-anlage to produce defects either to mark a selected point, determine the regulative power, or study the spread of the determination process [*Goldschmidt* 1920, Giersberg 1929, *Henke* 1933a, Magnussen 1933, and Kühn & Engelhardt 1933 (Lepidoptera)].

7. **Chemical analyses** [various workers, see Needham 1929, *Wigglesworth* 1934a, and Hoskins & Craig 1935].



8. **Modification of environmental factors** [used by various workers: Shull 1929 ff., (temperature and light on aphids); Plunkett 1926, Driver 1931, Goldschmidt 1931b and Luce 1935 (temperature on *Drosophila*); Kühn 1926 ff., Süffert 1924, *Feldotto* 1933 (temperature on moth wing-patterns); Geigy 1931 irradiation of *Drosophila* with ultra-violet rays), etc., etc.].

9. **Genetic analyses** of 'normal' mosaics, intersexes and gynandromorphs [used by various workers, notably Goldschmidt 1922, 1931a (Gypsy moth); *Sturtevant* 1929 and Dobzhansky 1931 (*Drosophila*)].

### III. HORMONES IN DEVELOPMENT

1. **Nymphal ecdysis (moulting) hormone:** In the blood-sucking bugs *Rhodnius* and *Triatoma*, Wigglesworth (1934b, c, 1935) has definitely shown the presence of an ecdysis or moulting hormone which is the same for all nymphal stages. This is proved by the fact that insects sharing the same blood moult simultaneously irrespective of age. Ecdysis normally occurs at a definite interval after feeding but if the head is removed or the nerve cord severed in the prothorax before a certain critical period the insect continues to live but does not moult. Accordingly there must be some stimulus from the distended abdomen transmitted via the ventral nerve cord to the brain which in turn initiates ecdysis. Presumably the hormone is secreted by the corpus allatum since this is the only gland associated with the brain that shows histological changes at this time and since severing the nerves between the brain and corpus allatum seems to prevent moulting. The hormone is not species specific since the effect can be induced in *Rhodnius* by blood from the related genus *Triatoma*. It is not the direct agent of ecdysis; it stimulates the epidermal cells which in turn accomplish the moulting process.

2. **Larval ecdysis (moulting) hormone:** This is also dependent on an active hormone which is non-specific for either stage or species, but whether or not the ecdysis hormone of nymphs and larvæ are the same chemically cannot be ascertained until at least one of them has been isolated.<sup>2</sup> The moulting of starved

<sup>2</sup> Their being the same would not particularly affect, much less invalidate, Berlese's theory of metamorphosis (see Introduction) which makes nymphs and larvæ non-homologous stadia.

individuals proves conclusively that growth is not the direct cause though it must be a factor (Pruthi 1925, Titschack 1926).

Buddenbrock (1930) injected blood from caterpillars ready to moult into caterpillars that had just moulted and obtained some premature moulting. Bodenstein (1933a) transplanted caterpillar legs onto younger and older caterpillars of the same stadium—the transplant and host moulted synchronously. The same effect was obtained by transplanting legs to different species of the same genus, thereby showing the nonspecificity of the hormone.

Also, although doubtless under hormonal control, it is unknown why certain species vary in the number of moults, especially variation between different seasonal broods of a single species (Arendsen Hein 1920, Roubaud 1927 and others). Kogure (1933) suggests that increase in the number of moults of the silk-worm larva is caused by lack of food, decrease by climatic factors, especially light and temperature. However, at least in the locusts, an additional moult is controlled by inherited factors of a sex-limited or sex-linked nature (Key 1936). The only conclusion that can be made is that change in the number of moults may be the result of either specific genetic factors or any of several environmental factors. Further data are necessary before a satisfactory explanation can be formulated (compare variation in diapause phenomena, section VIII).

**3. Nymphal metamorphosis:** Wigglesworth (1934b, c, 1935) demonstrated a second chemical (hormone) in the blood which is responsible for metamorphosis from the nymphal condition to adult in *Rhodnius* and *Triatoma*. Precocious metamorphosis can be induced in fourth or even first instar nymphs by 'perfusion' with blood of a fifth (last) instar nymph. This hormone must be in the nature of an inhibitor which is produced in quantities near the threshold value since simple mixing of the blood of a moulting fourth instar nymph with blood of another fourth instar nymph decapitated soon after feeding, with consequent dilution of the hormone, causes both to metamorphose. This, as well as the origin of the hormone, is also shown by transplanting the corpus allatum from a fourth instar nymph into a fifth instar nymph; the latter develops into a nymph instead of an adult. It is not yet certain whether the nymphal and metamorphosis hormones are

chemically distinct or only two different quantitative expressions of a single substance. Like the ecdysis hormone it is not species specific.

**4. Pupal metamorphosis:** The onset of pupation is due to a hormone which is probably qualitatively different from the larval ecdysis hormone. However, in the light of the following data, it does not seem clear as to whether this 'pupation hormone' should be viewed as a positive stimulator of pupation or the release of an otherwise autonomous organism from a previous inhibitor or both. Also, it is not clear whether the factors which break diapause (*q. v.*) are similar to those which cause metamorphosis or whether other factors are involved.

Kopeć (1922a) reported a certain critical period before which removal of the brain of a caterpillar inhibited pupation whereas later removal had no effect. He therefore postulated the brain as an internal secretory center or stimulator, but later (1927) questioned the interpretation. Caspari & Plagge (1935) repeated these experiments on sphinx moths and obtained similar results. They also report that if a brain from a normal mature caterpillar is transplanted into a caterpillar de-brained before the critical period, pupation ensues (they make no mention of the corpus allatum but unless they transplanted this gland along with the brain their data will not fit into the general picture as given here). They also report that if a larva is completely constricted before the critical period only the anterior part pupates. Buddenbrock (1930) accelerated pupation by injecting blood of pupating caterpillars into younger ones. Sometimes, however, he obtained only ecdysis which might indicate that moulting and pupation hormones are qualitatively the same. Bodenstein (1933a) reported that transplanted larval legs moulted synchronously with the host even when older than they would have been at the time of metamorphosis if left on the donor, but that they were invariably cast off at pupation. From this he inferred that pupation not only differs quantitatively from ecdysis but that it is caused by different factors (hormones). Conclusive data are presented by Fraenkel (1934, 1935) who reports that if blow-fly prepupæ are securely ligatured not more than twelve hours before pupation both parts pupate, the posterior part 1-3 hours after the anterior,

but if prepupæ are ligatured more than twelve hours before pupation only the anterior part pupates or else neither does. If the ligature on an early prepupa is removed both parts pupate at the same time (proving that injury is not responsible for the non-pupation of the posterior parts). This is definitely shown to be a hormonal effect by injecting blood of prepupæ about to pupate into the posterior parts of prepupæ ligatured 24 hours previously. Such posterior halves, which would never have pupated without the injection, pupated in about 50 per cent of the cases although some required a second injection 24 hours after the first.

The Lepidoptera and most of the other orders of insects possess well developed corpora allata (see Ito 1918), and, in view of Wigglesworth's data on *Rhodnius* nymphs, it is natural to look to these glands for the source of the hormones in holometabolous insects. However, the higher Diptera are said to lack any homologue of this gland; no suggestion can be made as to the source of the secretion other than that it must be produced in the anterior end of the body.

This conception of two competing hormones, one stimulating growth, the other inhibiting metamorphosis, also provides an explanation of prothetely (appearance of pupal characters in the larva) and metathetely (retention of pupal characters in the adult) if we assume that the first represents a premature release of certain of the embryonic tissues from the influence of an inhibitor, the second the failure of such release at the normal time (Wigglesworth 1934a, c). The startling report by Brecher (1932) of the development of two adults of the butterfly *Vanessa* direct from the larva without pupation may be an extreme case of this sort of hormonal unbalance, but the brief abstract published is not convincing since she was unable to ascertain whether or not the crumpled larval skins adhering to the adults contained pupal skins.

**5. Imaginal or adult metamorphosis:** The data for this subsection are considerably less conclusively than those for the above hormones. Frew (1928) reports that imaginal discs of blow-fly larvæ will not evaginate in carefully filtered (bacteria-free) larval blood but will evaginate and form a segmented limb in similarly



prepared pupal blood. By varying the inorganic salts he shows that this is not due to any change in the osmotic pressure of the body fluids. Bytinski-Salz (1933) transplanted ovaries and wing-anlagen of non-developing hybrid moth pupæ into normal pupæ (*i.e.*, parent stock of the hybrids). He found that these organs which will not develop in the donor do develop normally and completely under the influence of a normal host. Conversely, ovaries of normal parents transplanted into hybrids show no development before the host dies. Bytinski-Salz therefore postulates a developmental center at a particular time and place in the pupa, and further that this center acts as or controls an internal secretory center. It would seem from these data that in addition to a hormone causing pupation there is another hormone (or quantitative expression of a hormone?) necessary for the development and differentiation of the adult within the pupa.

When the growth processes of the pupa are disturbed by centrifugation or by operations performed on larvæ, histiogenesis may be retarded and the adult emerge while its internal tissues are still in a stage characteristic of the pupa. In such cases completion of the histological differentiation may take place in the adult (*Lina populi*, a beetle, Guareschi 1934b; *Drosophila melanogaster*, Richards unpubl. data).

**6. Reproduction:** Wigglesworth (1935, 1936) reports that the corpus allatum of the adults of *Rhodnius* and *Triatoma* produces a hormone distinct from the moulting and metamorphosis hormones of nymphs. This hormone controls the production of eggs. Adults deprived of this gland do not develop eggs, but adults deprived of it and receiving blood from another adult which possesses this gland produce eggs in normal manner. A similar effect is quite possible in holometabolous insects since, for instance, Ito (1918) shows that the corpus allatum of various Lepidoptera increases in size and presumably in functional activity in the adult.

**7. "Hormones" affecting genetic characters:** There are a few cases in which recessive genetic colors are suppressed by the presence of dominant-type tissue within the individual. This may be either by a contact-diffusion effect or by a more general

effect via the blood. In the moth *Ephestia* and in *Drosophila* it is proven that the "hormone" is not the product of any single organ or tissue—seemingly it is a more or less general property of dominant-type tissues.

Dobzhansky (1931) reports that genetically white testes (recessive color) become yellow with age in gynandromorphs of *Drosophila simulans* which contain wild-type tissue. Sturtevant (1932) reports that vermilion eye-color is almost always suppressed in gynandromorphs when wild-type ovarian tissue is present although other organs or tissues are also concerned. This has been conclusively proved by Ephrussi & Beadle (1934) and Beadle & Ephrussi (1935) by transplanting vermilion eye-anlagen of *Drosophila melanogaster* into the abdomen of wild-type hosts—the grafted eyes develop the wild-type coloration. They also report a similar suppression of cinnabar eye-color in wild-type hosts. They tested numerous other eye-colors and found that only vermilion and cinnabar were suppressed or changed. A. R. Whiting (1933, 1934) has shown a similar relation between recessive eye-color and some part of the abdomen in gynandromorphs of *Habrobracon* (wasp). Caspari (1933) reports that in the moth *Ephestia* testes from black-eye stocks with colored testis sheath (dominant character) implanted into larvæ of red-eye stock with colorless testis sheath (recessive allelomorph) give brown- or black-eye adults with partially colored host testes; and that colorless red-eye stock testes implanted into black-eye stock larvæ become partially colored regardless of whether the host is male or female. Caspari has thereby shown an effect of dominant-type tissue upon recessive-type tissue irrespective of which is graft and which host, that this effect is transmitted through the blood, and that the chemical ("hormone") that produces the effect cannot be the product of any single organ or tissue.

There is only one case of the modification of a genetically dominant character in gynandromorphs. Sturtevant (1932) reports a contact effect of non-bar tissue (recessive) on bar tissue (dominant) in certain parts of the eyes of *Drosophila*. He adds that the data may possibly indicate a time of determination effect (see Section V-A).

#### IV. THE 'DIFFERENTIATION CENTER' AND THE INFLUENCE OF THE NERVOUS SYSTEM

In the last section it was shown that stimuli from the brain to some other part of the body are necessary for the production of most (perhaps all) of the hormones now known to be concerned in larval and pupal development. In addition to this hormonal control there is the observable fact that in holometabolous insects the visible differentiation of the adult body begins in the pupal thorax and spreads thence anteriorly and posteriorly just as does differentiation of the larval structures in the embryo. That this represents a gradient-field phenomenon (see Section VI) similar to that of the embryonic differentiation center is indicated by two different sets of experiments: First, Geigy's report (1931b) that sensitization and desensitization to ultra-violet rays proceeds from the anterior part of the thorax posteriorly. Second, Bodenstein's report (1934, 1935) that fore leg anlage transplanted to hind leg positions develop the histological structure of fore legs but the form and size of hind legs. These data seem explainable only on a gradient-field concept such as a developmental center, especially since studies on regeneration (*q. v.*) show that the nervous system does not directly affect the differentiation of external form.

Hacklow (1931) made extensive experiments on various butterflies attempting to show that this differentiation center is located in the thoracic nervous system. Although there seems to be a differentiation center in the pupal thorax, its location in the nervous system is questionable. What has been shown (Crampton 1899, Kopeć 1922a, Hacklow 1931, Geigy 1931b, Hey 1932, Guareschi 1934) is: (1) that sensitization and desensitization to ultra-violet rays and centrifugal force (determination) proceed from the anterior part of the thorax posteriorly; (2) presumably also from the thorax anteriorly (as in the embryo) since there is clearly no developmental center in the head; (3) that differentiation of the abdominal segments does not occur if thoracic differentiation is inhibited or if the abdomen is separated from the thorax, but (4) abdomens grafted in natural or unnatural positions onto other pupæ develop normally although only the superficial tissues fuse, and (5) the thoracic and/or cephalic ganglia are somehow concerned either as causal factors (Hacklow) or as a link in a chain of reactions (Kopeć, Wigglesworth (1934a)).

Two contrary sets of data seem likely subject to other interpretations rather than consideration as exceptions. Crampton (1899) obtained adult parabiotic twins from two pupæ fused in the mesothoraces. Each member had only the posterior half of the mesothorax, the metathorax and the abdomen (thereby lacking any anterior thoracic differentiation center), yet normal and complete development ensued. An effect prior to the time of operation seems likely (exact ages not given). Metalnikov & Korvine-Kroukovsky (1927) claim that destruction of any ganglion of the bee-moth larva inhibits metamorphosis and that the metathoracic ganglion is most important since its destruction causes paralysis.

Unfortunately Peredél'skii's paper (1930) could not be obtained.

The conclusion, then, is that the 'differentiation center' is not a function of the nervous system, and that the influence of the nervous system is limited to stimulating the production of the hormones already discussed, to controlling (probably *via* hormones) the development of pupal- and perhaps also wing-coloration of butterflies (Brecher 1924a, b, Giersberg 1929), and to affecting the histological differentiation of certain internal tissues, notably muscles (see Section V-C).

## V. ORGAN DEVELOPMENT

### A. *The Eye and Central Nervous System*

Lew (1934) analyzed the normal development of the nymphal and adult eye of various dragonflies by making minute scars in the hypodermis of the nymphal head capsule. By experiments on various species he shows that the functional nymphal eye contributes only a small part of the adult eye in lower forms, and that in higher forms the nymphal eye is either reduced to a small, functionless area at the posterior margin of the eye or lost entirely. Further, that the adult eye develops by receiving new tissue from instar to instar from a budding zone at the inner margin, this new tissue consisting of incompletely developed ommatidia which do not become functionally mature until the adult stadium. Histologically he differentiates three types of tissue which together make up a mosaic eye: the first forms the func-



tional nymphal eye which is displaced and functionless in the adult *Libellulinae*; the second (covered by wrinkled cuticle in the nymph) forms the large facets of the adult eye; and the third (the one structurally incomplete in the nymph) forms the small facets that comprise the greater part of the adult eye. The adult eye of *Odonata*, then, is not just an enlargement of the nymphal eye but is composed largely or entirely of areas of the head capsule outside the boundaries of the functional nymphal eye.

The eye is a self-differentiating system. It is not dependent on the brain since Kopeć (1922b) showed that when the brain of a caterpillar is removed the complete set of ommatidia develop down to the lamina ganglionaris, the only effect of the absence of the brain being that the nerve fibers growing in from the retina are irregularly directed. The anlage is also independent of its position within the body, since when it is transplanted into the hypodermis of the abdomen it undergoes complete differentiation producing the full quota of normally and fully developed ommatidia although it makes no connection with the nervous system (Kopeć 1922b). Ephrussi & Beadle (1934) and Beadle & Ephrussi (1935) obtained similar but less complete results with *Drosophila*. The flies differ from the moths in that the eye anlage is invaginated into the body cavity instead of being part of the head capsule. The reversed relationships (pigment cells outside, lenses inside) reported by Beadle & Ephrussi for their *Drosophila* grafts is probably due to a failure of the anlage to evaginate.

No attempt will be made to review the voluminous genetic work on the eye of *Drosophila*. Study of mosaics, gynandromorphs and transplanted eyes show that the colors usually undergo autonomous development determined by the genetic constitution of the tissue. The only exceptions are vermilion and cinnabar (see Section III-7). The extensive series of colors is partly due to various combinations of the several pigment elements (see Schultz 1935). The bar-eye series of mutants show in part a dependence on temperature and modifying genes (Driver 1931, Hersh 1931, Luce 1935), but in addition that there is a central region of the eye in which complete facets are always formed, an adjacent anterior region in which pigment is present but facets not formed unless 'not-bar' tissue is near by, and a further anterior region

in which neither pigment nor facets are formed normally but in which both pigment and facets may be formed if 'not-bar' tissue is near by (see Sturtevant 1927, 1932).

Kopeć (1922b) reports that the eye anlage exerts a positive influence on the development of the brain. When the eye anlage of the gypsy moth is removed the optic ganglia of that side do not develop unless the eye is regenerated. From this it appears that the development of the optic ganglia is dependent on the ingrowth of nerve fibers from the retina. For the interdependence of the various parts of the central nervous system in later differentiation there is little data other than the observation by Kopeć that removal of the brain (supræesophageal ganglion) of a caterpillar results in marked underdevelopment of the subesophageal ganglion in the adult, whereas removal of the subesophageal ganglion does not effect the development of the brain.

#### *B. The Reproductive System and Secondary Sexual Characters*

Numerous experiments on moths, beetles, flies and crickets all show that surgical castration has no effect on the genitalia, genital ducts or secondary sexual characters, even when the castration is performed in early embryonic stages (Oudemans 1899 Kellogg 1904b, Meisenheimer 1908a, b, 1909a, c, Kopeć 1908, 1910, 1911, Hegner 1908, 1911, Regen 1909, 1910, Prell 1914, 1915, Klatt 1919, Geigy 1931a, Hamaski 1932, and Howland & Robertson 1934). Similarly, moth gonads transplanted into hosts of the same or opposite sex develop normally and have no effect on the host although they may fuse with the host gonads or genital ducts (Meisenheimer 1908b, 1909c, 1910, Kopeć 1910, 1911, Umeya 1926, Caspari 1933). The independent development of the gonads is further shown by the differentiation of moth testes *in vitro* (Goldschmidt 1917). And, finally, the absence of sexual hormones affecting differentiation is corroborated by the fact that although differences have been reported between the blood of the two sexes (Steche 1912, Geyer 1913), blood transfusion in moths gives only negative results (Kopeć 1911, Umeya 1926), and regenerating antennæ of moths reproduce the sexually dimorphic characters even though the individual has been castrated and a gonad of the opposite sex implanted (Kopeć 1913b).

Gynandromorphs are in themselves natural experiments proving the generality of the independent development of both the primary and secondary sexual characters. However, one exceptional case has been reported from gynandromorphs: Dobzhansky (1931) says that testes in gynandromorphs of *Drosophila* differentiate only when in contact with vasa efferentia (the male ducts, however, develop irrespective of the gonads) and degenerate in the presence of female ducts, especially if in contact with them.

Sex reversal in insects has been obtained by only three methods: (1) genetic constitution based on interaction of male and female factors (Goldschmidt 1927, 1931a, c, Dobzhansky & Schultz 1934); (2) abnormal temperatures based presumably on a difference in the rate of action of the sex factors (Goldschmidt 1934); and (3) the action of parasites (*Stylops*) on Aculeate Hymenoptera (Salt 1927, 1931). The first may be partial or complete, the second and third are always partial. The action of parasites is somehow related to the nutrition of the larva since Salt points out that it occurs only in those forms which receive a fixed ration for larval life and since its degree is increased when several parasites are present. It is also in keeping with Goldschmidt's theory of sex determination since there is a definite sequence of the appearance and change of the characters affected. No such sex reversal occurs, for instance, in the parasitic castration of aphids by braconids (Paillot 1934). [Phasic, nutritious and other kinds of castration are elaborately reviewed by Wheeler (1910).]

An entirely different type of interaction is shown by the genitalia of mosaic males of the wasp *Habrobracon*. According to Whiting's theory of sex determination in Hymenoptera (Whiting 1933) there are two types of haploid males, and females result from the interaction of these two genetic types in a diploid individual (diploids resulting from the fusion of two gametes of the same type are usually non-visible but very rarely live and become diploid or biparental males. See Part I, section IV, 3). In mosaic (haploid) males containing both of these types of tissue, Whiting, Greg & Speicher (1934) report a feminization of the genitalia due to the interaction of the two types of haploid tissue present in the individual.

### C. Muscles

Kopeć (1923) reported that the muscles of the larva of the gypsy moth do not atrophy following removal of the corresponding ganglion even when several ganglia were removed and all innervation thought broken (possibility of nerve plexi remaining). However, muscles appear in the adult in only those segments in which the ganglia of the larva were not damaged. Similarly, Kopeć (1923) and Šuster (1933) found that when a leg or antenna and its corresponding ganglion are both extirpated from moth larvæ or mantid nymphs, the appendage may regenerate externally normal but without muscles or nerves (and so functionless). Friedrich (1930) reports that in regeneration of legs in phasmids nerves appear sooner than muscles. These data prove that the differentiation of insect muscles is dependent on their being innervated even though the mature muscle, unlike vertebrate muscles, will not atrophy following severing of its nerves.

### D. The Epidermis and Segmented Appendages

The differentiation of the epidermis cannot be due to the influence of the nervous system or other internal organs because of the data from regeneration cited in the last paragraph. Rather, the epidermis and appendages show the effect of the interaction of gradient-fields (see Section VI). Bodenstein (1934, 1935) shows that the problem may be divided into two subheads: (1) general form, (2) histological structure. By transplanting fore leg anlagen of third instar larvæ of the butterfly *Vanessa* to the site of extirpated middle and hind legs he found that the general form became largely transformed to that typical of middle and hind legs but that the histological structure (in this case special scale types) remained more or less typical of fore legs, the degree of similarity depending on the quantitative relationships of the two anlagen which interact to form a single leg. General form of the leg, then, becomes modified to fit its new position within the organism but the histological structure is already completely determined by this stage.

The histological differentiation of the epidermis in homœosis and heteromorphosis (Section VI), unlike that in the trans-



plantation of anlagen from third instar larvæ, is normal for the structure developed. This implies not only a considerable degree of potency beyond the prospective significance of the anlage, but that prior to the chemo-differentiation of the anlage its development is under the influence of a gradient-field whether it be in the course of normal development or of regeneration.

The reasons for the differentiation of sclerites are unknown. Anomalies in abdominal segmentation (see Section VII) show that whatever determines the general metamerism of the body also secondarily determines what parts of the abdominal epidermis will form sclerites and what parts will form membrane. The pattern of sclerites in the head and thorax is more complex, and it does not seem advisable to theorize on their determination at the present time.

The differentiation or absence of specialized cuticular sense organs in antennæ and legs regenerating without innervation is not mentioned by either Kopeć (1923) or Šuster (1933). Šuster showed by electrical and mechanical stimulation that such appendages were functionless, but that might be due merely to lack of muscles and lack of connection with the central nervous system. While one would expect the terminal sense organs to be absent in the absence of innervation, no one has reported on the point. The analysis of *Drosophila* gynandromorphs (Sturtevant, 1929) suggests that the determination and differentiation of the thoracic setæ is somehow brought about by their position. Perhaps some day the determination of sclerite and setal patterns may be interpreted as special gradient-field phenomena.

#### *E. Wings and Wing-Patterns of Lepidoptera*

The determination and differentiation of insect coloration is a complex problem. From this field the wing-patterns of moths and butterflies is selected as representative and as having received the most extensive study. Experimental studies on the coloration of Orthoptera are presented by Przibram (1919d), of the bug *Pyrrhocoris* by Henke (1924), of the beetle *Leptinotarsa* by Tower (1918) and of the wasp *Habrobracon* by Kühn (1927) and Kaestner (1931). The physics and chemistry of the colors is omitted (see Prochnow 1927, Imms 1931).

The wing and its pattern represents a self-differentiating system as is proved by the normal development (per origin) of sexually dimorphic wings transplanted onto the opposite sex (Kopeć 1922c), by the *in vitro* development of pattern in fully formed but colorless wings (Charin 1930) and by the frequently delayed development of operated wings (Goldschmidt 1920). The last two sets of data also show that the pattern is not a rhythmic phenomenon of the body and not directly related to the blood. However, Giersberg (1929) reports that if the head is amputated from larvæ of the butterfly *Vanessa* the adults are scaleless [Kopeć (1922a, b) does not mention any such effect in his de-brained gypsy moths].

From the extensive works on normal wing-development only a few relevant points can be mentioned. The primary tracheal system of the wing is mapped out by blood lacunæ before the growth of tracheæ into the anlage. This primary tracheation is different from the secondary or adult tracheation (Köhler 1932, Henke 1933a, Behrends 1935, Kuntze 1935). The adult wing is not coextensive with and frequently not the same shape as the pupal wing. The margin of the definitive wing becomes clearly marked on the pupal anlage by a marginal blood-channel, the reasons for the development of which are not known (Süffert 1929b). Although the two are normally correlated the pattern is largely independent of the gross form of the wing and of the veins and tracheæ (see Henke 1933a).

In many cases the pattern becomes partially visible before the development of any color due to the differences in scale-types (Goldschmidt 1923). These visible but non-color differences do not appear simultaneously but, like the colors themselves, appear at different times for the different pattern elements (Goldschmidt 1923, Köhler 1932, Henke 1933a). A corollary of this is the correlation of scale-type with particular coloration, both of which are normally correlated to the position within the pattern (Kühn & Henke 1932). Experimental studies to be cited below show that the wing-coloration is completely or almost completely determined long before the appearance of any pigment; developmental studies show that in the case of melanism the black pigment appears simultaneously throughout its definitive extent and

is not merely a continued production of melanin after the formation of the normal pattern (Witt 1933). A point of considerable potential significance is Köhler's report (1932) that in *Ephestia* there is a definite pattern of mitoses throughout the wing (in both the ordinary and scale-forming cells); the areas of maximum number of mitoses representing the future dark pattern elements, the minimum areas the future light pattern elements. He reports that this correlation of mitosis and maculation patterns can be carried out to details. If this is found to be of general application it will be of great importance since it will show that the result of determination is, at least in part, operative by affecting the metabolic rate of the particular cells concerned, and it will suggest that this is one of the primary effects of chemo-differentiation. It would also give a quantitatively measurable method (rate of mitoses) of studying the physiological processes involved in pattern and color development. It would be premature, however, to imply that this might be concerned in the production of different types of pigments; in *Ephestia* it is correlated only with the quantity of the melanin pigments.

The outstanding point in the determination of wing-patterns is that prior to the appearance of any pigment there are relatively brief '*sensitive periods*' during which the various pattern-components can be modified by external agents, and before and after which they are not affected by the same agents.<sup>3</sup> In passing from an undetermined to a determined state the cells pass through a period during which they are sensitive to, *i.e.* can be modified by, certain environmental factors. The components of the pattern do not all have the same sensitive period, and the same elements do not necessarily have the same time of determination in different species although they are constant in any one species (varying from late larva through early pupa). By applying heat, for instance, at slightly different times it is possible to modify one part of the pattern without in any way altering the other parts or the same parts on the other wing of the same side of the body. Correspondingly, by treatment through several or all the sensi-

<sup>3</sup> "Sensitive periods" are by no means confined to the determination of wing-patterns although they are not discussed in any other connection in this paper. See the various references given in Section II, no. 8 ("Modification of environmental factors").

tive periods it is possible to alter several or all of the recognized components (Prochnow 1914, Süffert 1924, Kühn 1926, Giersberg 1929, Feldotto 1933, and other older authors). Kühn reports that treatment at the beginning of a period reduces the size of the spots on the wing of *Argynnis* whereas later treatment increases their size.

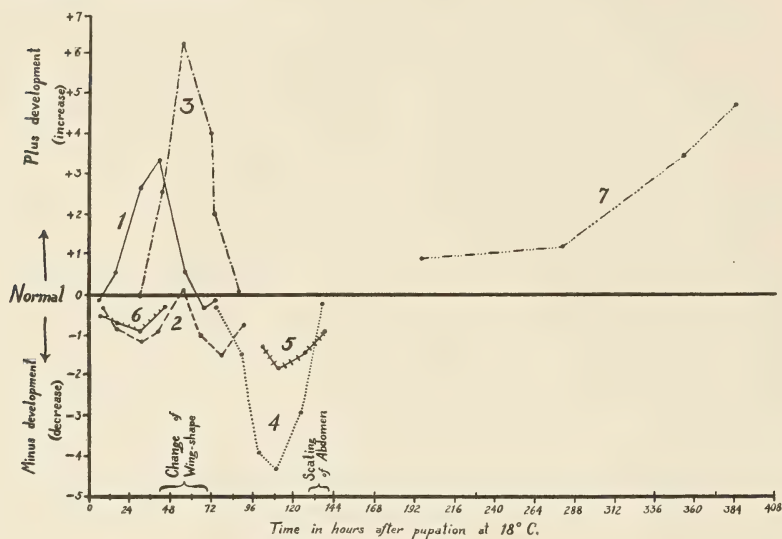


FIGURE 1.—Time of and curves of the various sensitive periods for the wing-pattern of *Ephestia kühniella* Zeller during the pupal stage. (After Feldotto, 1933.)

Legend: 1 (——) Number of dark scales in the marginal fringe; 2 (— — — —) degree of development of the cross bands of the symmetry-system; 3 (— . — . —) fusion of the cross bands of the symmetry-system; 4 (.....) loss of the marginal fringe; 5 (—|—|—|—|—) loss of maculation by loss of the scales from the wing-surfaces; 6 (—|—|—|—|—) development of transparency of the background or substrate; 7 (— · — · — · —) darkening of the background (true melanism). Brackets show time of sensitive periods for change of wing-shape and development of scales on the abdomen (curves for these two not determined).

[Feldotto used timed pupæ space at 6 hr. intervals from 1–120 hours.; 12 hr. intervals from 120–336 hrs., and 36 hr. intervals from 336–408 hrs. Data mostly obtained from animals placed at 44.5–45.5° C. for 45 minutes (optimum temperature for species 18° C.). Used 4611 experimental animals (of which 3420 were at ages of 1–156 hrs.) of which 1013 were modified to a greater or less degree. 1191 controls.]



It seems of especial interest that the fundamental pattern elements recognized by comparative-morphological studies (Schwanwitsch 1924, 1929, 1930, Süffert 1927, 1929a, Henke 1933b, c) are the same as those mapped-out by physiological analysis (Kühn 1926, Feldotto 1933). Further, in *Ephestia kühniella* genetic analysis of wild populations has resulted in the isolation of stocks which have the same pattern as certain temperature aberrations (Kühn & Henke 1929). So, in all reported cases, a morphological component (e.g., a particular line or particular row of spots) always acts as a unit, whether modified by temperature, simple mendelian genes or interspecific differences, but is independent of the other components. Each pattern component in *Ephestia*, as well as the scales themselves, their transparency or pigmentation, and even wing-shape, has a characteristic curve for its sensitive period (Fig. 1).

The external agents that produce these aberrations are heat, cold and certain narcotics. They cannot represent a direct effect on pigment formation since heat and cold may produce identical forms. It is a general rule that mild temperatures lighten the color, more extreme temperatures darken it. The various postulates are discussed by Giersberg (1929) who also performed experiments showing that the effect of temperature on pupæ of *Dilina tilia* is only through the head. By passing water of the desired temperature through glass tubes laid alongside the pupa he found that changing the local temperature of the body or wing during the sensitive period was without effect but that changing the temperature of the head resulted in typical aberrations. Although he had only twenty specimens he says that the results were absolutely consistent and that the effect must be *via* the nervous system, the quantity of black pigment depending on some particular stimulus from the head. How this acts is not clear. He adds that the situation must be more complicated in *Argyannis* where the pattern elements vary independently. Schulze (1918) distinguished darkening by increase in number of black scales from darkening by a general blackening independent of scale number and this is experimentally substantiated by Feldotto's data. Study of Feldotto's graph (Fig. 1) shows that enlargement of the lines (bands), fusion of lines and spots, etc., are de-

terminated during sensitive periods occurring early in pupal life (curves numbers 1, 2, & 3) but that general blackening of the ground occurs much later (curve number 7) and after the pattern is fully determined. It would seem that the cephalic control obtained by Giersberg resulted in a general blackening effect without relation to (although obscuring more or less completely) the pattern, and that this cephalic control affects only the quantity of melanin produced and does not directly affect the pattern itself.<sup>4</sup>

The determination of the wing-pattern seems to be due to a '*determination stream*' "flowing out" over the wing-anlage and determining the pattern parts. First postulated by Goldschmidt (1922, 1923, 1934) from analysis of intersexes, the idea has been continued by Minami (1925) and Giersberg (1929) in studies on such abnormal specimens. Goldschmidt also postulated the idea of a correlation of this determination stream with different developmental velocities of the several parts of the pattern (based on the different times of their development), but Giersberg shows by localized cooling of the wing anlage of *Vanessa* during and after the sensitive periods that the pattern develops first in the warm areas, later in the cool areas, yet a normal wing always results. From this it follows that the developmental velocities have no influence on, or at least can be changed without modifying, either the color or pattern.

It is interesting to note that the structural colors, as well as the pigmentary colors, follow these lines of determination streaming. This seems likely only a special case of the determination of scale-type which is normally correlated with the determination of the color-pattern. It might be well to emphasize the fact that it has not been possible to separate the determination of scale-type, structural colors and pigments. Either they are determined coincidently or else the scale-type *ipso facto* determines the quality of both structural and pigmentary colors.

<sup>4</sup> The experimental induction of melanism in geometrid moths by chemicals (lead and manganese salts) and the melanics thereby obtained are not included in this discussion because Harrison & Garrett's experiments have been repeated with negative results by Hughes and by Thomsen & Lemche. For a summary of the evidence see Fischer (1933).

The comparative-morphological studies already mentioned have led to the idea of a *central symmetry-system* occupying approximately the median two-thirds of the wing and distinct from the basal and terminal parts of the pattern. Kühn & Engelhardt (1933) and Henke (1933a) show by injury experiments that the determination of this symmetry-system in moths is independent not only of the ocelli but also of the basal and terminal areas. Kühn & Engelhardt report that during the second and third days of pupal life of *Ephestia kühniella* this process spreads as a determination stream from the lower surface of the wing over the anterior and posterior margins and then proximally and distally independently of the wing veins (Fig. 2). They consider the symmetry-system as representing a self-differentiating system in contrast to the basal and terminal areas which are limited in extent by the development of the central system. Henke adds that the pattern of the terminal area represents a 'filler' of the space between the symmetry-field and the wing margin and that its pattern is illustrative of processes occurring on the periphery of a field.

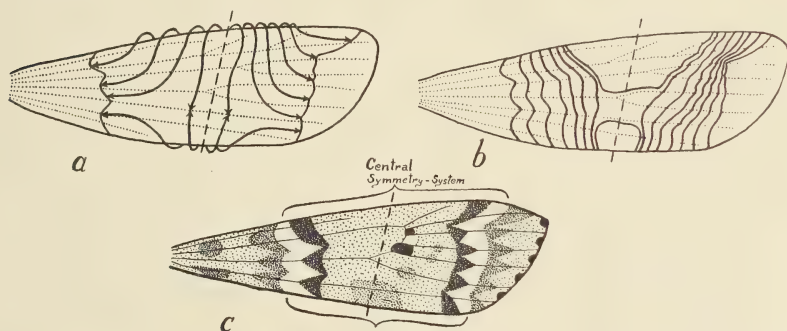


FIGURE 2. *a*. Scheme of the distribution of the determination process of the symmetry-system of *Ephestia kühniella* Zeller as determined by local defects on the wing epithelium of 1-2 day pupæ. *b*. Scheme showing the outer boundaries of the various degrees of development of the symmetry-field following operations (local defects) on the wing anlage of 1-3 day pupæ. *c*. Diagrammatic representation of the normal wing-pattern of *Ephestia kühniella* Zeller (the limits of the central symmetry-system are indicated by brackets; the axis of the symmetry-system is shown by a broken line.) (After Kühn & Engelhardt, 1933.)

Two different types of determination processes or streams have been discussed above: (1) a determination stream "flowing out" from the wing base, and (2) a determination stream spreading from the median portion of the ventral surface over the median portion of the dorsal surface. Perhaps these are fundamentally different processes since gypsy moth intersexes show a normal symmetry-system in addition to a more or less longitudinal blotching of the sexual dimorphic coloration.

The mode of action of these determination processes (and other processes of chemo-differentiation) are unknown. It seems certainly not a matter of developmental velocities (Giersberg 1929, see above). The distribution of the process is better known. Giersberg (1929) reports that local defects on *Vanessa* winganlagen can produce a change in the pattern, and that this change is best explained by the postulation of the distribution of two immiscible substances during the sensitive periods, impregnation with which results in the determination of the pattern and color, interference with which hinders the distribution of one and allows greater distribution of the other. In the case of the central symmetry-system (Kühn & Engelhardt 1933, Henke 1933) it seems that the determination of this central region of the wing limits the relatively passive development of the pattern and color of the basal and terminal areas, and therefore is in close agreement with Giersberg's postulate. Gebhardt's (1912) and Hutterer's (1932) data (see below) show that the distribution of the determination process is quite similar to dispersion in colloidal solutions (Liesegang's rings). They were able to prepare gelatine and paper models that are remarkably similar to certain rather complex butterfly patterns by such dispersion phenomena from one to five centers, sometimes aided by folding the substrate. The dispersion of the determination process over the wing by some such controlled diffusion or dispersion spreading is undeniable; of what the determination process consists physico-chemically is unknown.

A comparison showing the relation between 'sensitive periods' and 'determination streams' can be given only for *Ephestia kühniella*. In this species Kühn & Engelhardt found that no determination had begun on the first day after pupation, that the



determination process proceeded during the second and third days, and was completed on the fourth day. Comparing this with Feldotto's curves (Fig. 1) we find as one might expect that the sensitive periods for the development and fusion of the cross-band (*i.e.*, development of the symmetry-system) fall largely within this time.<sup>5</sup> The determination process "flows like a stream" across the symmetry-system determining the parts thereof. The sensitive period is a brief stage between undetermined and completely determined tissue. The one is a process, the other a stage in that process. Naturally the two are closely related, and their interdependence is shown by the fact that an entire pattern-component varies as a unit or else not at all.

The *ocelli* or *eye-spots* on the wing are determined prior to the symmetry-system and are not influenced by its determination (Henke 1933a, Kühn & Engelhardt 1933, Magnussen 1933). Although the discoidal ocellus normally has a definite relation to the discoidal vein (Henke & Preiss 1930, Bryk 1931), Henke (1933a) found that the ocellar anlage of *Philosamia cynthia* bears no relation to the veins and is not influenced by operations on the tracheæ. He reports that the determination of an ocellus takes place in two steps: (1) the production of the ocellar-anlage on both wing surfaces (not in the same area where the ocellus later develops), and (2) the expansion and organization of the various zones in definite order of precedence from the inner parts outwardly. The latter is independent on the two wing-surfaces, the former is not. Gebhardt (1912) and Hutterer (1932) point out similarities between these determination processes, especially ocelli, and the purely physical formation of Liesegang's rings in colloidal solutions. Some of the figures they obtained are quite suggestive. Perhaps some of the complex multiple line and concentric ring figures found in certain Lepidoptera are the result of a determination process that disperses in the manner of Liesegang's phenomena.

As will be discussed later (Section VIII) Süffert (1924) showed that the seasonal forms of *Araschnia* are due primarily

<sup>5</sup> Only two of the seven curves given by Feldotto (Fig. 1) are concerned here. These are curves numbers 2 and 3. The other five curves are not or at least not directly concerned with the determination of the symmetry-system.

to the type of development undergone by the pupa. Thus diapause pupæ give the "spring form" and non-diapause pupæ normally give the "summer form" regardless of whether kept cold or warm. This is complicated by the fact that non-diapause pupæ can be made to give the "spring form" coloration by the application of cold during the brief sensitive period. But the fact that diapause pupæ can never be induced to produce the "summer form" unless the diapause is broken (in which case an intermediate results, the degree of intermediacy being correlated with the length of the diapause period before its interruption) implies that the type of development is the primary cause of seasonal forms at least in this species (see also Heller 1928). The experiments of Weismann (1875, 1876), Edwards (1875), Merrifield (1911) and other older authors on various species corroborate this. It seems quite probable that this explanation is of general application, and that the differences between "dry" and "wet" season forms of butterflies may have the same explanation.

These data are also quite significant to taxonomy. They show that the so-called "aberrations" are not really aberrant, and that these "aberrations" have no direct bearing on phylogeny or evolution. The production of these does show that the insect is capable of producing unusual results, but the fact that any given "aberration" can be produced practically at will and the specific results predicted with considerable accuracy merely by altering a particular component of the environment shows that there is no inherent difference between so-called normal and aberrant colorations of lepidopterous wings (naturally an accurate knowledge of the sensitive periods and careful timing of the breeding is prerequisite to predicting results). "Aberrations" are merely normal individuals which have developed under not normal conditions during some or all of the sensitive periods.<sup>6</sup>

<sup>6</sup> It is true that similar effects may result from genes and interspecific differences, but it does not follow from that that "aberrations" have any direct relation to phylogeny. Indistinguishable results do not necessarily imply that the cause is the same, and the experimental data show conclusively that "aberrations" are only normal individuals and so have no phylogenetic status. Erroneous reasoning on the part of certain individuals has lead them to think that "aberrations" were of phylogenetic significance, and to devise "systems" to show their evolutionary significance. All that "aberrations" show

### F. Imaginal Discs of Higher Diptera

By detailed analysis of ninety-six gynandromorphs of *Drosophila simulans*, Sturtevant (1929) has shown not only that the cleavage nuclei are clearly indeterminate (since there is never any indication of a general pattern among mosaics) but also that the presumptive imaginal discs are mapped out at an early stage. He selected thirty-six parts showing mosaicism and, tabulating his data, says, "There appear to be modes at 18, 9 and 5 parts male. These correspond to 50 per cent, 25 per cent and 13 per cent of the possible 36 parts. Evidently they correspond also to cases in which one of the first two, first four or first eight cleavage nuclei were male, *i.e.*, to elimination of an X chromosome at the first, second or third cleavage division respectively." This indicates that the cortical protoplasm of the egg of *Drosophila* is not only determined for the parts of the embryo but also (perhaps secondarily) mapped out for the adult via the imaginal discs. These data are valid only for prospective significances.

Geigy (1931b) reports that the imaginal anlagen are not predetermined in the cortical layer of the egg since he was unable to produce imaginal defects by ultra-violet irradiation before the time of contraction of the germ band (*i.e.*, after the embryo is formed). Therefore he postulates two determination periods for the higher Diptera: the first for the embryo and larva, the second for the adult via the imaginal discs. The first is completed by the time of fertilization, the second is not finally completed until the pupal stadium since similar defects can be produced by irradiating larvæ and young pupæ. But Smith (1935) reports similar non-hereditary defects from x-irradiated female gametes and thereby leads to questioning the validity of Geigy's two determination periods. Perhaps the discrepancy can be traced to the different types of irradiation used but it seems best to leave it an open question.

Sturtevant (1929) further shows that some imaginal discs (*e.g.*, wing discs) regularly contain more blastoderm nuclei than other

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is that the wing is capable of producing patterns different from that usually found (they also afford a method for studying pattern determination). Comparative studies of the pattern within a group may, and frequently do, give indications of the evolution within that group, but "aberrations" do not.

smaller discs (*i.e.*, the size of the disc is a fair indicator of the number of blastoderm nuclei it contains). That in keeping with the distances apart of the points of origin of the imaginal discs, adjacent segments of one side of both thorax and abdomen are much more alike than are opposite sides of any one segment, *i.e.* the visible points of origin of the imaginal discs give an accurate picture of the earlier positions of their presumptive anlagen. That there is no determinate cell-lineage within the discs although related cells clearly tend to remain together; the differentiation of the cells (*e.g.*, setæ) occurs later independent of their origin but somehow brought about by their position. And that the prospective significance and prospective potency of the discs are almost identical since dorsal thoracic and abdominal discs only rarely produce parts belonging to the other side of the body (*vide* 'half-thorax' specimens), but that this is less rigid for the cephalic discs which seem not to give rise to sharply demarcated regions of the head.

#### G. 'Self-Differentiation' of Anlagen

The above sections on organ development show that, except for the necessity of growth and metamorphosis hormones, the various parts represent largely self-differentiating systems, *i.e.*, the various organs and parts are usually capable of development independently of the parts normally associated with them. This is admirably demonstrated by the complete development and differentiation of testes and the almost complete differentiation of leg anlagen *in vitro* (Goldschmidt 1917, Frew 1928), by the development of gonads transplanted into the opposite sex (Meisenheimer, Kopeć, etc.), by the development of mosaics and gynandromorphs, by the development of eye anlagen implanted into the abdomen (Kopeć 1922b, Beadle and Ephrussi 1935), by the inside-out development of a twin embryo within the body of its partner (Seidel 1929), and by the striking case of a genetic stock of the Gypsy Moth which is wingless yet in which the pupal cases possess the characteristic wing-pockets (Goldschmidt 1927).

Cases of an organ or part being dependent on another part or on the body as a whole (except for the hormones already mentioned) are less common. The outstanding cases are the absence



of muscles in the absence of the corresponding ganglia (Kopeć 1923, Šuster 1933); the failure of testes to differentiate in gynandromorphs of *Drosophila simulans* unless they make contact with the male ducts and their degeneration when in contact with female ducts (Dobzhansky 1931), and the modification of the external form and size of butterfly leg anlagen to correspond to their position within the host (Bodenstein 1935). The first shows the necessity of innervation for muscle development; the second an unique case of the dependence of developing testes on their ducts; and the third presumably an interaction of gradient-fields in leg development (see Section VI). Another type of interaction is in the feminization of genitalia in mosaic males of the wasp *Habrobracon* (Whiting, Greb & Speicher 1934). Stylopodization ("parasitic castration") of Aculeate Hymenoptera, frequently involving a partial sex-reversal, is another special case that has been discussed above.

## VI. REGENERATION AND GRADIENT-FIELDS

Of all the topics covered in this paper regeneration was the first to receive experimental study. As early as 1829 Heineken reported that the antennæ of young cockroaches were capable of being regenerated following amputation; in 1837 Müller reported the same for phasmid legs, and in 1844 Newport reported the regeneration of legs in Lepidoptera. Hundreds of papers have followed—of these only a selected set can be cited to illustrate the important points and the extent of the work. The results show considerable regenerative power for the external parts of various species of Thysanura, Odonata, Orthoptera (saltatorial and gressorial), Ephemera, Hemiptera, Thysanoptera, Dermaptera, Embiidina, Coleoptera, Lepidoptera and Hymenoptera, and also for certain internal organs of Lepidoptera. Unfortunately no direct data are available for the Diptera except Kammerer's questionable paper (1907) on the regeneration of the wings of adults, but 'hereditary homœsis' or the development of an Anlage into a structure typical of a different region of the body (*e.g.*, an antenna replaced by a tarsus) might possibly be compared with heteromorphic regeneration to be discussed below (Bridges & Morgan 1923, Astauroff 1929, Balkaschina 1929, Bridges & Dobzhansky 1933).

As Huxley & DeBeer (1934) and others have pointed out, regeneration is distinct from embryonic regulation discussed in Part I of this series. During early embryonic stages the loss of a small portion of tissue does not necessarily imply the loss of any particular anlage since regulation is possible within a gradient-field. Later, at different times in different insect groups, the various anlagen become chemo-differentiated ("mosaic stage of development"), and regulation is no longer possible (Part I, Section VI). Later still the power of regeneration appears. Regeneration is intimately associated with growth, and the onset of the capacity for regeneration is connected with the onset of the capacity for growth. "Regulation and regeneration must therefore be carefully distinguished, since they involve developmental processes which are very distinct, and are operative at different periods of the life cycle" (Huxley & DeBeer, 1934, p. 419).

*A. Structures Reported Capable of Regeneration—  
A Literature Index*

*Nymphs and larvæ: Antennae* (Kopeć 1912a), 1913, Brecher 1924c, Gabler 1932, Lengerken 1933, Friza & Przibram 1933, Šuster 1933a, Sweetman 1934); *compound eyes* of beetles, moths and phasmids (Werber 1905, Kopeć 1913a, 1922b, Janda 1926); certain caterpillar and beetle *mouthparts* (Megušar 1907b, Kopeć 1912a, 1913a); *legs* (Kellogg 1904a, Megušar 1907b, Janda 1910, Kopeć 1923, John 1923, Duskova 1926, Benazzi 1929, Heldmann 1929, Šuster 1933b, Sweetman 1934); *spiracles* (Staudinger 1930); *imaginal discs of wings* of beetles, moths, dragonflies and mantids (Megušar 1907b, Meisenheimer 1908c, 1909b, Janda 1910, von Ubisch 1911, Kopeć 1913a, 1922c, Kříženecký 1914, Magnussen 1933, Oka & Furukawa 1933); *cerci* of Thysanura and Dermaptera (Sweetman 1934, Furukawa 1933); *bristles, body warts and caudal horn* of lepidopterous larvae (Megušar 1907a, Kopeć 1912a, 1913a, Bodenstein 1930, 1933a, e); *larval gills* of dragonflies (Perfiljew 1923); and the entire *terminal abdominal segment* of young nymphs and larvae (Megušar 1907b, Kříženecký 1913) or even the two or three terminal segments including the internal organs (Megušar 1907b, Oppenheim 1908).

*Pupæ*: Crampton (1899) reported no regeneration of lepidopterous antennæ and wings but merely formation of integument

over the wound. However, Hirschler (1903) reported partial regeneration of the amputated last three abdominal segments of young moth pupæ, including specific organ regeneration (hind gut and genital ducts). Kříženecký (1912), Magnussen (1933) and Henke (1933a) report that defects on pupal wing anlage are not regulated although those on larval anlage are (loss of regulative as well as regenerative power in pupa).

*Adults:* Werber (1907) and Kammerer (1907) report the partial or almost complete regeneration of wings extirpated from freshly emerged beetle and fly adults. In the beetle *Tenebrio* Werber reports that the elytron regenerates only when the wing is also removed. In the flies *Musca* and *Calliphora* Kammerer reports a compensatory reduction of the unoperated wing following unilateral extirpation and during regeneration. These results were based on very few specimens and seem never to have been repeated. The photographs accompanying the papers look authentic, but in addition to a general skepticism the present author suggests that the "compensatory reduction" really represents the partial collapse of the unhardened wing following reduction of the blood pressure caused by removal of one wing, due at least in part to loss of blood and perhaps also in part to the shock of the operation.

Przibram (1932, 1935) observed the development of a wing-like structure on the wounded coxa of an adult mantid. This is reminiscent of Richardson's (1889) finding in nature a moth one of whose legs was replaced by a wing. Przibram also reports that an antenna of *Sphodromantis* amputated on the day of metamorphosis can regenerate as a small segmented appendage and that earlier antennal regenerates can continue to develop during adult life. Thysanuran adults continue to moult and show regenerative powers (Sweetman 1934).

*Internal organs:* The gonads are never regenerated (Meisenheimer, Kopeć, Regen, *et al.*); neither is any part of the central nervous system (Kopeć 1918, 1922b, 1923, Šuster 1933). However, the egg ducts and proximal part of the vas deferens of moths are frequently regenerated (Kopeć 1923, Caspari 1933), and also the hind gut and genital ducts in the cases of regeneration of the terminal abdominal segments (Hirschler 1903). Fat and tra-

cheæ of moths metamorphose normally despite operations and seemingly exhibit a certain amount of regenerative power (Kopeć 1923) but the wing tracheæ become finally determined and incapable of regulation about the time of pupation (Henke 1933a). Muscles regenerate and appear in the adult only when the ganglion of the segment is left intact (a leg or antenna may regenerate externally normally but without muscles or nerves when both ganglion and appendage are extirpated. Kopeć 1923, Šuster 1933). Friedrich (1930) reports that the order of regeneration of the internal tissues of the leg of the mantid *Dixippus* is nerves and tracheæ, then muscles and sense organs. He believes the tissues are all derived from the epidermal part of the organ-stump. In a certain sense the transformation of the muscles and digestive epithelium during pupal life can be considered regeneration, as may also the renewal of the worn out digestive epithelium throughout life.

### *B. Summary of Results from Regeneration*

*Stages during which regeneration occurs:* (1) Regeneration other than mere wound healing is usually possible only at the time of ecdysis, and the reproduced part becomes more nearly perfect with subsequent moultings. (2) Accordingly, regeneration is not to be expected in the adult except in the Thysanura which continue to moult after attaining maturity. The cases of slight or continued regenerative-growth of antennæ and the development of a wing-like structure on a wounded coxa in *Sphodromantis* are exceptions. (3) However, regenerative-power is to a considerable degree a function of age (not merely a matter of the number of days or moults available), and the degree of regeneration is inversely proportional to the age of the insect (Megušar 1907b, Magnussen 1933).

*The frequency and degree of regeneration:* (4) More complex and highly differentiated organs, *e.g.* compound eyes, are regenerated less often than less complex organs. (5) The regenerated part may be normal structurally yet reduced in size; more often it is of normal size but structurally imperfect or incomplete. (6) Bodenstein (1935) says that the degree of development of the adult leg of the butterfly *Vanessa* is independent of the time of



the operation but dependent on the amount of material removed and the spatial relations of the developing leg. (7) Sexual dimorphism of moth antennæ is developed to the same degree in normals and regenerates even when the animal has been castrated and a gonad of the opposite sex implanted (Kopeć 1913). (8) However, as one would expect, heterogonic sexual characters are not reproduced in regeneration in phasmids (Przibram 1931).<sup>7</sup>

*Suppression of regeneration:* (9) Body-wart or leg regeneration may at times be suppressed by transplantation of some other hypodermal part to the site of the amputation provided the transplant covers the entire wound-surface. But if the transplant does not cover the entire wound-surface there is a regeneration from the free surface in addition to the development of the transplant (Bodenstein 1933a, c, d, e). [See also number 10.]

*Determination and differentiation in regeneration:* (10) In at least most cases regeneration is possible only when a stump of the organ remains, i.e., a proximal part is capable of regenerating any distal portion but the animal is incapable of regenerating the entire structure (Przibram 1919c, Schaxel & Adensamer 1923). (11) Regeneration, as far as known, is controlled by the organ stump, not by the position within the body, since when a thoracic leg of a caterpillar is transplanted onto the abdomen or an abdominal leg transplanted onto the thorax and the distal part then amputated, the quality and orientation of the regenerate is determined by the transplanted stump (Bodenstein 1933e).<sup>8</sup> (12) The differentiation of a regenerating antenna has been reported as proceeding in a proximo-distal direction (Kopeć 1913a) but, although sometimes thus, this is not necessarily true for all structures (e.g., caterpillar legs, Bodenstein 1933e). (13) Regenera-

<sup>7</sup> Heterogony in insects, according to Huxley (1932), is produced by the utilization of food reserves above the amount needed for normal growth. For this reason one would not expect the reduplication of heterogonic characters in regeneration in insects when the reserve has been unexpectedly called upon to replace a normal organ instead of merely elaborating an organ that is already present (just as heterogonic characters are not or are only slightly developed in females where the food reserve is needed for the development of eggs). The time factor may also be concerned.

<sup>8</sup> No experiments comparable to those showing the non-specificity of regeneration-buds in Amphibia have been performed with insects.

tion of epidermal structures is independent of the nervous system; regeneration of muscles is dependent upon their being innervated.

*Heteromorphic regeneration:* (14) At times regeneration may be heteromorphic, *e.g.*, an amputated antenna regenerates as a leg or an eye as an antenna-like structure (Janda 1913, Friza & Przibram 1933). In all cases reported for insects the heteromorphic structure is one typical of a more posterior region of the body. Przibram (1934) reports that the percentage of phasmid antennae regenerating as legs (in contrast to ones regenerating as antennae is increased by (a) amputation from older individuals, (b) amputation of a greater portion of the organ, and (c) lowering the temperature during regeneration. These facts suggest a gradient-field relationship (see below). (15) There is no absolute relationship between the level of section and the type of regeneration but there is a tendency for an amputated antenna to regenerate as an antenna if cut through the flagellum, as a leg if cut through the basal two segments (Brecher 1924c, Friza & Przibram 1933). Borchardt's claim (1927) that the Johnston's organ in *Dixippus* exerts a truly formative influence on the regenerating antenna is refuted by Friza & Przibram (1933) who found no constant relationship, and also by a comparative study in phasmids where only certain genera exhibit heteromorphic regeneration regardless of whether the Johnston's organ is removed or left in the antennal-stump (Przibram 1931). (16) Balkaschina (1929) reports that acceleration of the rate of development of antennal anlagen of *Drosophila* to the rate of development of normal leg anlagen, by gene action, results in an 'antennal foot.' Friza & Przibram (1933) cite this as supporting Przibram's hypothesis (1919b) that relative developmental velocities affect the type of regeneration. Przibram (1919a), Benazzi (1929, 1931), Bodenstein (1933e) and others all maintain that 'normal' regeneration represents local acceleration of growth, but the different growth-rates mentioned here are not necessarily comparable. In conclusion it seems best to say that although there is sometimes a correlation between developmental velocity and type of regeneration, it remains to be proven whether or not there is any causal relationship between the two.

### C. *Gradient-Fields*

A gradient-field is a region with a central or terminal high or dominant point with a graded degree of the potency concerned from this high point outward in all directions or along a main axis. It may include the entire organism, for instance the primary axis of the egg, or only a portion of the organism, for instance a limb-field in Amphibia. Gradient-fields have been extensively analyzed in *Planaria*, Amphibia and certain other forms, and a detailed discussion of these data is given by Huxley & DeBeer (1934). The inclusion of the topic here is largely based on comparison with these other groups.

Hartzell (1934) reports that the anterior end of the larva of the Tomato Worm moth (*Protoparce sexta*) is more susceptible to pyrethrum extracts than the posterior end. This implies a longitudinal gradient of susceptibility with a high point at or near the anterior end of the body though it may be due to the nervous system rather than the body as a whole. The action of the embryonic differentiation center is another example of a longitudinal gradient whose high point is in the thoracic region. More comparable data are supplied by Bodenstein (1935) who transplanted the fore legs of caterpillars onto middle and hind leg positions. He found that the adult legs developed from such transplants had the histological structure (special scale-types) of fore legs but the form and size of middle and hind legs. This is analogous to the modification of Anuran presumptive belly epidermis grafted into the future mouth region of an Urodele egg where it gives rise to Anuran type mouth tissue, which Huxley & DeBeer (1934, p. 321) call the interaction of a gradient-field of primary effect with one of secondary effect. Bodenstein also reports that the ectodermal part of the larval leg lying outside the area of the presumptive adult leg anlage is capable of inducing leg-regeneration. This could be compared with Amphibia where the limb-field is of greater extent than the presumptive limb. Goldschmidt (1921) makes use of another of the principles of gradient-fields to explain duplication in the male genitalia of intersexual Gypsy Moths. He noted that the chitinous ring of the ninth abdominal segment was much broader in intersexes than normals. Since both valves and penis develop from a single

anlage, the valves beginning to develop next to this ring, a space is left between the developing valve and penis. He says that two high points develop when this spatial isolation is sufficiently large, and, accordingly, two valves develop, one next to the segmental ring, one next to the penis. All of these data can be explained on a gradient-field hypothesis.

The comparison of gradient-fields in insects with those in other animals is most fruitful when regeneration is considered. There are two important points: (1) Regeneration is usually possible only when the stump of an organ remains. This is strictly analogous to the absence of regeneration in Urodeles after removal of the entire limb-field in contrast to complete regeneration when only part of the field is removed. (2) Heteromorphic regeneration, as pointed out by Huxley & DeBeer, is best explained by the assumption of a flattening of a gradient-field since that is the only concept which will systemize the data summarized above under numbers 14-16.

## VII. TERATOLOGICAL PHENOMENA

No attempt will be made to cover the subject of teratological phenomena in detail. Pro- and metathetely have already been mentioned in Section III-4, and homœosis and heteromorphosis in Section VI. A few additional notes will be given and the reader is referred to Przibram (1920) for a detailed classification.

*Duplications and triplications* have been mentioned in Part I. They may be experimentally produced by dividing an anlage mechanically (see Part I), by duplication of anlage by transplantation performed in such manner that both anlagen develop (Bodenstein 1933c, e), or, presumably, by the development of two high points in a gradient-field (See Section VI-C). Bateson (1894) pointed out that in triplications, whatever the mode of origin, the several structures always lie in the same plane and that two of the components are always mirror-images of one another (duplications may or may not be mirror-images). Bateson's rules have been abundantly confirmed by Przibram (1921) and others, but the cause of the formation of mirror-images is still obscure and has given rise to considerable controversy. For a theoretical discussion see Przibram 1924.



*Anomalies in body segmentation:* In Part I it was pointed out that duplication in the longitudinal axis of the body is unknown. However, certain anomalies of segmentation do occur either naturally or as experimental by-products. Usually they appear sporadically but in some cases they (or the tendency to form them) are definitely heritable. Cases of so-called "spiral segmentation" (not to be confused with "spiral cleavage" of molluscs, annelids, etc.) have been reported by Cockayne (1929, 1934) and Learned (1932) for various moth larvæ, by Arendsen Hein (1920) for the beetle *Tenebrio*, by Cappe de Baillon (1927) for *Dixippus* and by Morgan (1915) for *Drosophila*. They are presumably the result of fusion of one segment-half with the opposite half of the succeeding segment during formation of the definitive embryo or to a similar incorrect fusion of imaginal discs in the pupa (*Drosophila*). The first might be due either to some obstacle to growth in the proper direction or to movements of the embryo during closure of the dorsal body wall (see Part I, Section VIII). The comparative rarity of ventral spirals might be due to either greater proximity or earlier fusion or both. Their principal significance in this paper is that they seem to show that whatever is responsible for the metamerism of the organism also secondarily determines what parts of the epidermis will form sclerites and what parts intersegmental membrane.

Abdominal sclerite defects (usually not "spirals") are common in *Drosophila*. In some cases they are heritable (Morgan 1915). They are especially common from irradiated eggs which indicates that the presumptive imaginal discs are highly determinate and possess little of any regulative power after injury (Geigy 1931b, Smith 1935). Stark (1918) and Richards (unpubl. data) have noted that following the mechanical injury of transplantation in *Drosophila* larvæ sclerite defects almost invariably occur in the adult. Usually this is merely the loss of part of one or more sclerites, but in one case following a dorso-lateral incision I obtained 'typical' spiral segmentation of the adult abdomen (doubtless the incision or the scar interfered with growth of the imaginal discs so that the disc destined to form one side of a segment fused with the one which should have formed the opposite half of the succeeding segment instead of the one forming the

opposite half of the same segment). No torsion of the abdomen results from these anomalies, the lost sclerite-parts are replaced by or at least their area filled with membrane. Abdominal sclerite defects have also been produced by centrifuging beetle pupæ (Guareschi 1934).

### VIII. DIAPAUSE OR DORMANCY<sup>9</sup>

Hibernation is not necessarily the same as diapause. Bodine (1923, 1932b) shows that hibernation is not inherent but is conditioned solely by temperature even in species which do not normally hibernate. Hibernating animals have a lower water content but the rates of oxygen consumption and growth respond to changed temperature in similar manner to non-hibernating individuals.

Diapause, in distinction to hibernation, is an inherent, obligatory characteristic which may be independent of temperature for its occurrence though its duration is affected by temperature and other factors. It is manifested as a retardation or cessation of growth, mitosis, metabolism and movements (Slifer 1931, 1932). It occurs at different stages in different species but almost always at a particular developmental stage in any one species.

For the egg of the grasshopper *Melanoplus*, Bodine (1925, 1929, 1932a, b, c, 1934a) and Burkholder (1934) have shown that the diapause factors are quickly destroyed or inhibited at low temperatures and much more slowly at high temperatures; that diapause represents an "all or none" type of reaction with a definite threshold value which is reached at a definite time after laying and at a particular development stage; and that above the development zero (18° C.) diapause is independent of temperature for its occurrence but is relatively dependent on temperature for its duration. Some species have an optimum temperature (Parker 1930).

Bodine (1934b) and Bodine & Boell (1934a, b) report that the oxygen consumption of developing eggs is markedly depressed by KCN to a small constant fraction of the unpoisoned respiration of

<sup>9</sup> I acknowledge with thanks the criticism of Dr. David R. Goddard during the preparation of this section on diapause.

normal eggs whereas diapause eggs are almost completely resistant to the same concentrations. This is strikingly analagous to the action of KCN on fertilized and unfertilized sea-urchin eggs. They also report that the oxygen consumption of developing eggs is depressed by CO to a similar constant low level; that the oxygen consumption of diapause eggs or of developing eggs poisoned by KCN is stimulated by CO, and that this is due to the concentration of the CO rather than the length of exposure. From these two sets of data they conclude that respiration in diapause is quantitatively and qualitatively identical with the KCN and CO insensitive fractions of the respiration of developing eggs at the same morphological stage, and that therefore in diapause the respiration is depressed not merely as a passive result of decreased protoplasmic activity but by the complete suppression of the KCN and CO sensitive part of the respiratory mechanism by some unknown agent acting as part of the general diapause-producing factor.<sup>10</sup>

Comparing diapause and growth factors Bodine (1932c) states that the diapause factors are completely destroyed or inhibited at low temperatures whereas growth factors are only temporarily inhibited at low temperatures and quickly return to normal when placed at high temperatures. He views the diapause factors as inhibitors which beginning below the threshold value in quantity or potency increase to a point where they inhibit the growth factors completely. Later they become reduced to below the threshold value and then the growth factors resume activity. Wigglesworth (1934a) prefers not to invoke a second (inhibitor) factor. He suggests that diapause is due simply to the temporary failure of the growth promoting hormone. The available evidence does not permit making a choice between these two hypotheses. Roubaud's theory of autointoxication by waste products, while in certain respects similar to Bodine's theory, does not

<sup>10</sup> This, of course, does not mean that the respiratory changes are in any way the direct cause of diapause. In fact, Bodine (1934c) has shown by varying the osmotic pressure that the block mechanism of *Melanoplus* eggs is not primarily concerned with the general oxidation metabolism of the cell, and that the oxidation limits of the dormant cells may be modified without interfering with the diapause mechanism.

seem adequate to explain the great diversity of diapause phenomena throughout insects (Roubaud 1922, etc.)

Investigation of temperature coefficients, respiratory quotients, iron, peroxidase and tyrosinase content of *Melanoplus* eggs has shown no significant relationship to diapause (Bodine & Boell 1935a, b, Bodine & Thompson 1935, Bodine & Walkin 1934, and Boell 1935).

The above deals exclusively with the eggs of the grasshopper *Melanoplus* but the major premises are valid for diapause in other insects and at later stages. In eggs of the moth *Lymantria monacha*, Knoche (1932) reports that the differences in the level of respiration of diapause and non-diapause eggs vary. Therefore the degree of diapause varies in different eggs of the same species, and it is possible to intensify this difference in respiratory level by raising the humidity and to decrease it by lowering the humidity. He also reports that the time of onset of diapause is correlated with the respiratory rate (soonest when this rate is relatively high during diapause, later when it is low). In this connection it is interesting to note Readio's data (1931) on nymphs of the bug *Reduvius* in which diapause may occur at several different stages. Using growth curves he noted that diapause is progressively more intense in the later stages of nymphal development, and that the appearance of a dormant period in the third or fourth nymphal stadium usually obviated a diapause period in the succeeding stadium, and, conversely, its absence in either of these stadia was invariably followed by dormancy in the next stadium. This suggests to the present author an activation-deactivation-reactivation phenomenon based perhaps on fluctuations in the quantity or potency of the diapause-producing factor from above to below the threshold value and back again. [Experimentally produced activation-deactivation-reactivation has been reported for certain cases in plants.]

Bodine & Evans (1931-1934) report that the oxygen consumption and temperature relationships in diapause of wasp larvae are similar to those in the grasshopper egg. They also report that normal or artificially produced diapause gives marked powers of resistance to or recovery from the harmful effects of immediately preceding x-irradiation. Most noteworthy of all, weak doses at



the beginning of diapause lengthen the period, stronger doses shorten it and still stronger doses break diapause and permit development to proceed although the organism eventually dies from the latent effects of the irradiation. The significance of these data from x-irradiation is not known.

Süffert (1924) reported that the different wing-patterns of spring and summer forms of the butterfly *Araschnia* are due to the fact that the spring form develops from pupæ which undergo a true diapause period whereas the summer form develops from pupæ which do not undergo diapause (see also Heller 1928). The primary difference between spring and summer forms is therefore the type of development—the wing-maculation being only a secondary result (this is true despite the fact that the ‘spring form’ may also be produced by the action of cold during the sensitive period of wing development of non-diapause pupæ. See Section V-E).

Another peculiarity is that in many species some individuals of a single batch grown under identical conditions will reach the adult stage the first year, others the second year, and others only after several years (Calvert 1929, Faure 1932, Wolcott 1934 and others). It would seem that this is most likely due to differences in the physiological condition of the various individuals caused by differences in genetic constitution.

Whatever the cause of diapause it can frequently be broken by a variety of factors. These may be either environmental factors such as high or low temperature, light or certain chemicals (Radio 1931, Boyce 1931, Bataillon & Su 1931, Bodine *et al.* 1925–1935, Varley & Butler 1933, Sabrosky, Larson & Nabours 1933), friction, electrical or mechanical shocks (Roubaud 1922, Varley & Butler 1933), or parasitism (Salt 1927, Holdaway & Evans 1930, Davies 1930, Cousin 1932, Varley & Butler 1933). Among various Diptera parasitized by Braconids and Chalcids, Varley & Butler (1933) report that there is a striking difference in that in *Lucillia* everything points to the shock of the sting as the causative agent whereas in *Lipara* and *Urophora* the break in larval diapause is not so prompt and must in some obscure way be effected by the parasite itself within the host. The mechanics of how these varied factors operate to break diapause is totally

unknown, and ascribing diapause to hormonal action does little more than furnish a working hypothesis.

The above discussion has been concerned with the physiology of diapause and how it may be broken or prevented. A more or less separate set of data has to do with the experimental production of diapause. In the introductory paragraphs it was pointed out that diapause is an inherent characteristic which might be independent of temperature for its occurrence. That statement may be amplified by saying that when it is experimentally induced by temperature or other means it always differs from hibernation by its obligatory nature.

In the silkworm moth the number of generation a year (voltinism) is controlled by mendelian factors 'maternally' inherited (Uda 1923) but the eggs of the univoltine races incubated at high temperatures almost always produce moths laying non-diapause eggs, and the eggs of bivoltine races incubated at low temperatures usually produce moths laying diapause eggs. Kogure (1933) postulates two interacting substances, one affected by both light and temperature during the egg and less in the larval stages, the other affected by temperature alone during the pupal stage. According to this hypothesis these two substances interact to produce or control both the egg-color and diapause. In connection with this Umeya (1926) has shown by castration followed by ovarian transplantation that the voltinism of the eggs laid by the graft ovaries is absolutely controlled by the genetic constitution of the host regardless of whether uni- or bivoltine. Despite largely negative results from blood transfusion it seems that this (as well as light and temperature control) is an effect of the somatic tissues (via hormones) on the growing oöcytes. It will bear repeating that diapause in the Silkworm is controlled by the action of factors upon the parent, not upon the generation affected. Roubaud (1935) has recently briefly reported a case of diapause in mosquitoes being dependent on the physiological condition of the mother.

Normally emergent forms of the *Polyphemus* moth can be induced to undergo a pupal diapause by low temperature treatment of the last instar larva or high temperature treatment of the eggs (Dawson 1931). Dormancy can be similarly induced in

larvae of wasps (Bodine & Evans 1934) and mosquitoes (Roubaud 1930).

In closing it might be pointed out that insect diapause is closely paralleled by similar phenomena in fungus spores, plant seeds and buds and even unfertilized animal eggs.

## IX. SUMMARY

1. Nymphal and larval ecdysis are both under hormonal control. In the bugs *Rhodnius* and *Triatoma* it has been proved that this hormone is secreted by the corpus allatum, and that its production is controlled by stimulation from the brain. This hormone does not directly cause moulting; it stimulates the ectodermal cells to produce the enzymes that do. (Section III, 1-2.)

2. Nymphal, pupal and adult metamorphosis are also under hormonal control, and the production of the hormone is controlled by stimulation from the brain. The hormone is probably qualitatively different from the ecdysis hormone. Several different hormones or quantitative expressions of a single hormone are indicated by the data. In the bugs *Rhodnius* and *Triatoma* the metamorphosis hormone is secreted by the corpus allatum but at a different time from the ecdysis hormone. In these bugs experiments prove that this hormone is an inhibitor, release from which allows metamorphosis to occur. Most insects possess well developed corpora allata but the higher Diptera lack these glands; the source of the hormone in Diptera is not known. (Section III, 3-5.)

The hormonal regulation of development is viewed as due to two competing hormones, one stimulating growth, the other inhibiting metamorphosis.

3. Ripening of eggs by the adults of *Rhodnius* and *Triatoma* is stimulated by another qualitatively different hormone secreted by the corpus allatum. Persistence of the corpus allatum in the adult stage seems to indicate a similar relation in other insects. (Section III, 6.)

4. "Hormones" are also known to affect certain genetic (mendelian) characters. In contrast to the above hormones they appear to be the product of several or all tissues of certain genetic constitution rather than the product of a particular gland. (Section III, 7.)

5. Differentiation in the pupa, as in the embryo, begins in the thorax and proceeds thence anteriorly and posteriorly. This seemingly represents a developmental center with a similar location to that of the differentiation center of the embryo. It is certainly not a function of the nervous system. It seems to partake of the nature of a gradient-field. (Section IV.)

6. The adult eye of hemimetabolous insects, at least of dragonflies, does not develop from the nymphal eye but is composed largely of areas of the head capsule outside the boundaries of the nymphal eye. The insect eye represents a self-differentiating system and is independent of the brain and even of innervation. The anlage is also independent of its position within the body.

The eye, however, does exert an influence on the development of the optic ganglia of the brain.

Almost nothing is known concerning the interdependence of the parts of the central nervous system during differentiation and later development. (Section V, A.)

7. Gonads, genital ducts and secondary sexual characters are almost without exception independent in development. The only clear-cut exception is the testes of *Drosophila* which appear to need contact with the genital ducts for differentiation. (Section V, B.)

8. Insect muscles do not atrophy following severing of their nerves. However, muscles appear in the adult in only those segments in which the ganglia are left intact. Innervation, therefore, is necessary for the differentiation of insect muscles. (Section V, C.)

9. Differentiation of the epidermis may be divided into two subheads: general form and histological structure. In legs of the butterfly *Vanessa* histological structure is determined early and cannot be modified, but general form is determined by the position of the developing limb (data based on operations on third instar larvæ). The differentiation of appendages is independent of their innervation and musculature. These data and heteromorphosis suggest a considerable potency for the presumptive epidermal parts under the control of a gradient-field. The reasons for the differentiation of sclerite and setal patterns are not known (function of position?). (Section V, D.)



10. The components of the wing-pattern of Lepidoptera are relatively independent of one another and of the gross form of the wing and its veins. The parts of the prototype pattern, obtained by purely morphological criteria, have been shown to be physiologically different. These different components have different 'sensitive periods' (to abnormal environmental factors) and different times of determination, both prior to the development of the pigment. The pattern is restricted to particular places by various morphogenetic processes which control both the structure of the scales produced and the pigment. The determination process may be viewed as a "streaming process," in some cases from the base of the wing distally, in other cases over the central field. The wing pattern includes at least two harmonious-equipotent systems: the central symmetry-system and the eye-spots or ocelli. Both of these are concentric arrangements of zones which after injury show tendencies toward dislocation, fusion and the formation of closed round figures. In *Ephestia* there is a correlation of mitosis-pattern of the anlage with the presumptive dark and light parts of the definitive wing-pattern. (Section V, E.)

11. The presumptive imaginal discs of *Drosophila* are already mapped out at an early embryonic stage. The data concerning their time of determination (chemo-differentiation) are conflicting. The prospective significance and prospective potency of these imaginal discs are practically the same, especially for the thorax and abdomen. (Section V, F.)

12. The above sections on organ development show that the insect body in larval and pupal stages is largely a mosaic of self-differentiating organs and parts except, of course, for the necessity of the developmental hormones. Chemo-differentiation of the anlagen occurs early, usually before or not later than the time of separation of their presumptive anlagen, and the parts differentiate independently according to this determination. The modification of external form of legs, seemingly representing the action of a gradient-field, is an outstanding exception. (Section V, G.)

13. Most of the external and certain of the internal organs of nymphs and larvæ are capable of being regenerated. The gonads

and parts of the central nervous system are never regenerated. The power of regeneration becomes greatly reduced in the pupal stage and is almost always absent in the adult (partly a function of age). The quality of the regenerate is usually controlled by the original nature of the organ-stump, and regeneration is usually possible only when a stump of the part remains. Regeneration is independent of the nervous system. Heteromorphic regeneration and certain other points suggest a gradient-field relationship. (Section VI.)

14. Duplications and triplications occur normally or may be induced. In triplications the structures follow Bateson's rule which states that the parts must lie in one plane and that one member is always a mirror-image of the other two. The origin of mirror-image formation is not known.

Anomalies in body-segmentation are common. This is particularly true of the abdomen where determination and differentiation last take place. (Section VII.)

15. Diapause or dormancy is an obligatory phenomenon which seems best viewed as due to either the presence of an inhibitory hormone or the temporary failure of growth hormones. It is manifested as a retardation or cessation of growth, mitosis, metabolism and movements. It may occur normally because of the inherent genetic constitution of the individual, or it may be induced either in the egg by factors in the blood of the mother or in the individual itself after the egg is laid by the action of certain environmental factors. It may be broken (artificially or normally) by a variety of means. It is closely paralleled by similar phenomena in other animals and in plants. (Section VIII.)

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## THE GENOTYPES OF THE NORTH AMERICAN HADENINÆ (LEPIDOPTERA, NOCTUIDÆ)

BY HARRISON M. TIETZ, PH.D.

STATE COLLEGE, PA.

(Concluded from page 107)

*Lophoceramica artega* Barnes. Fig. 24A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—peaked, not spinose; Marginal spines—a few; Corona—absent; Protuberances—a slender bent rod and a short process ending in a spine; Editum—present; Clavus—rounded; Ædæagus—not ornamented; Vesica—not ornamented.

*Tricholita semiaperta* Morr. Fig. 28A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Harpe—peaked and spinose; Marginal spines—one; Corona—absent; Protuberances—a curved strap and a smaller strap; Editum—present; Clavus—rounded; Ædæagus—without ornamentation; Vesica—with a single cornutus.

*Trichopolia dentatella* Grt. Fig. 32A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—none; Corona—none; Protuberances—an inwardly curved sclerotized bar and a small flat structure produced to a point; Editum—present; Clavus—rounded; Ædæagus—orifice hooked on one side, scobinated on the other; Vesica—with a cornutus.

### Group IV

No material available for a study of the male genitalia.

### Group V

In the two species included in this group, the harpes are constricted at their proximal portions.

*Epia echii* Bork. Fig. 49A.

Uncus—cygnated; Peniculus—absent; Scaphium—absent; Subscaphium—slight indication; Harpe—trigonal, spinose;

Marginal spines—absent; Corona—present; Protuberances—a flat lobe rounded at the tip and an irregular hook-shaped structure; Editum—present; Clavus—rounded; *Ædæagus*—without ornamentation; Vesica—with cornutus; Juxta—present.

*Admetovis oxymorus* Grt. Fig. 54A.

Uncus—diamond shaped; Peniculus—present; Scaphium—absent; Subscaphium—indications; Harpe—rounded; Marginal spines—present; Corona—present; Protuberances—a chitinous structure rounded at the end; Editum—absent; Clavus—produced, with short bristly hairs on the produced area; Sacculus elongated into a scleritized ridge; *Ædæagus*—with a cornutus at the base and a slight hook at the orifice; Vesica—with cornutus.

## Group VI

### Section A

#### Subsection Ia

Males of *Chabuata ampla* Wlk., *Aletia vitellina* Hub., and *Meterana pictula* White were not available for study, so cannot be included in the following discussion.

In this subsection there are eight genera whose relationships are not easy to determine. They seem to have much in common and structurally they overlap each other. If one may rely on the structure of the male genitalia to indicate relationships, then they can be grouped as follows:

- (1) *Ulolonche*, *Zosteropoda*, and *Neleucania*
- (2) *Melanchra* and *Hyssia*
- (3) *Ceramica*      (4) *Hyphilare*      (5) *Anarta*

On this basis only one genus may be considered synonymic—*e.g.* *Hyssia* with *Melanchra*.

*Ulolonche niveiguttata* Grote. Fig. 84A.

Uncus—simple; Peniculus—absent?; Scaphium—absent; Subscaphium—absent; Harpe—peaked, spinose; Marginal spines—absent; Corona—absent; Protuberance—a membranous fold and a long surved bar; Editum—present; Clavus—rounded; *Ædæagus*—without ornamentation; Vesica—with rows of teeth.



*Zosteropoda hirtipes* Grote. Fig. 91A.

Uncus—forked; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—present; Corona—absent; Protuberance—a curved strap; Editum—present; Clavus—produced and bearing a few bristly hairs; Ædœagus—without ornamentation; Vesica—bearing several small spines, one bulbed cornutus, and a small cornutus without a bulb.

*Neleucania niveicosta* Smith. Fig. 95A.

Uncus—forked; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded; Marginal spines—present; Corona—absent; Protuberances—half-way up the harpe a long curved spine, at the base a smaller curved spine; Editum—present?; Clavus—produced and bearing a few hairs; Ædœagus—with one large spine; Vesica—with several small spines.

*Melanchra persicariæ* Linn. Fig. 58A.

Uncus—tongue shaped; Peniculus—absent; Scaphium—absent; Subscaphium—large, diamond shaped; Harpe—trigonal, spinose; Marginal spines—absent; Corona—absent; Protuberance—a fold in the harpe; Editum—present; Clavus—produced, scobinated; Ædœagus—orifice with two lateral spines; Vesica—with cornutus.

*Hyssia cavernosa* Eversm. Fig. 65A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose; Marginal spines—a few; Corona—present; Protuberances—an irregular sclerotized ridge ending in a protruding disc; Editum—present; Clavus—rounded; Ædœagus—orifice provided with a ventral and lateral hook; Vesica—not ornamented.

*Ceramica picta* Harris. Fig. 72A.

Uncus—knobbed; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked and spinose, the dorsal border with two thumb-like projections; Marginal spines—absent; Corona—absent; Protuberances—a mere thickening of the wall of the sacculus; Editum—present; Clavus—rounded; Ædœagus—orifice provided with lateral hooks; Vesica—not ornamented.

*Hyphilare albipuncta* Schiff. Fig. 69A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—present; Corona—absent; Protuberances—a distorted “Y” shaped structure, one arm of the “Y” broad and the other narrow. There is also a curved spine; Editum—present ?; Clavus—produced; *Ædæagus*—without ornamentation; Vesica—without ornamentation.

*Anarta myrtilli* Linn. Fig. 76A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—asymmetrical, rounded; Marginal spines—.....; Corona—.....; Protuberances—left clasper a rough tapered arm, right clasper much larger produced into a peaked, flattened plate; Editum—.....; Clavus—rounded; *Ædæagus*—.....; Vesica—with a large bulbed cornutus.

## Subsection Ib

In this subsection there are fourteen genotypes but the males of four of them were not available for a study of their genitalia. These were *Dargida grammivora* Wlk. (*gramminivora* Wlk.), *Eriopyga punctulum* Gn., *Naesia moesta* Wlk., and *Borolia furcifera* Moore. The last three were placed in the same group with *Meliana*. *Meliana* is the only genotype of the group of which males were available. Whether male genitalia can be used to tie these four genotypes together cannot be determined until these structures have been studied in the other three genotypes. *Dargida gramminivora* Wlk. is the only species lacking in the “*Hadena*” group. On the bases of other characters, the eight genotypes of this group tie up very well but as soon as a study of the male genitalia is made the linkage does not seem so close. The “*Hadena*” group breaks up in such a way that *Hadena* is associated only with *Aethria*, *Astrapetis* and possibly *Diataraxia*. Even here one may have to stretch a point to keep the group together. The other five genotypes on the basis of their male genitalia are independent entities. At this point we are face to face with the question whether we should group these fourteen genotypes together because of similarity in frons, antennæ and

other similar structures or should they be split because their male genitalia show such differences.

I have chosen to keep them together because the male genitalia of other congeneric species must be studied before we can determine what genital characters are of generic value. The differences we note now may be specific and not generic.

*Meliana flammea* Curt. Fig. 143A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded; Marginal spines—present; Corona—absent; Protuberances—a tripartate organ, the inner lobe club shaped provided with a few spines; the middle a simple rod; the outer broad and flat; Editum—present, prominent; Clavus—irregular; Ædæagus—without ornamentation; Vesica—provided with a bunch of teeth and a row of small spines.

*Heliophila pallens* Linn. Fig. 147A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded and spinose; Marginal spines—present; Corona—absent; Protuberances—a stout curved strap and a slender rod; Editum—present; Clavus—slightly rounded; Ædæagus—without ornamentation; Vesica—with a band of teeth.

*Pseudorthodes vecors* Gn. Fig. 131A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, not spinose; Marginal spines—absent; Corona—absent; Protuberances—a large curved strap; Editum—absent; Clavus—rounded; Ædæagus—without ornamentation; Vesica—with cornutus.

*Hadena cucubali* Schiff. Fig. 99A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent?; Corona—absent; Protuberances—a fold and a papilla from the base of the cucullus; Editum—.....; Clavus—strongly scobinated; Ædæagus—with serrations at the orifice and extending along the vesica.

*Aethria serena* Schiff. Fig. 103A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—slight indications; Harpe—rounded; Marginal spines—few; Corona—present; Protuberances—a broad and flattened strap rounded at its tip; also a chitinous ridge; Editum—present; Clavus—strongly produced; Ædæagus—orifice with a lateral hook; Vesica—with a cornutus.

*Astrapetis dentina* Schiff. Fig. 107A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few; Corona—present; Protuberances—a chitinous ridge above which there is a flat strap ending in a round curved head; Editum—present; Clavus—rounded; Ædæagus—orifice with a long lateral hook; Vesica—with a cluster of spines.

*Diataraxia splendens* Hub. Fig. 110A.

Uncus—simple and covered with spines; Peniculus—present; Scaphium—absent; Subscaphium—consists of two or more chitinous bands; Harpe—rounded; Marginal spines—absent; Corona—present; Protuberances—a chitinous thickening with a slender spine. There is also a bipartate organ, one part of which is a rounded lobe and the other a short pointed rod; Editum—present; Clavus—slightly produced and bearing a few bristles; Ædæagus—orifice without ornamentation; Vesica—with two lobes, one bearing a large bulbed cornutus, the other with a small bulbed cornutus.

*Eupsephopaectes procinctus* Gr. Fig. 117A.

Uncus—diamond shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—trigonal; Marginal spines—absent; Corona—present; Protuberances—a very slender much curved rod bearing a few bristles at its tip. There is also a sharp, stout hook; Editum—.....; Clavus—scobinated; Ædæagus—without ornamentation; Vesica—without ornamentation.

*Crocigrapha normani* Grt. Fig. 120A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—indicated; Harpe—rounded, spinose; Marginal spines



—present; Corona—present; Protuberances—a flat “Y” shaped organ, one arm of which bears bristly hairs. There is also a curved rod terminating in a point; Editum—poorly developed; Clavus—produced; *Ædæagus*—orifice scobinated on one side; Vesica—with a bulbed cornutus.

*Aplecta nebulosa* Hufn. Fig. 124A.

Uncus—simple; Peniculus—indicated; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose. One angle is produced and bears a spine; Marginal spines—present; Corona—present; Protuberances—the sacculus provided with a terminal prominence which is spinose. The inner edge of the sacculus is very irregular, more so on the right side. On the right side there is also a curved hook hidden in the figure by the large spines. On the left side there is another more irregular hook and a small strap like projection slightly knobbed at its tip; Editum—present?; Clavus—very irregular; *Ædæagus*—without ornamentation; Vesica—without ornamentation.

#### Subsection II

There are twelve genotypes in this section, and all twelve are figured. They have so little in common with each other that there is no way to group them. There are two species which the writer expected to exhibit similar genital characters. These are *Nephelodes emmedonia* Cram. (*minians* Gn.) and *Monostola asiatica* Alph. Superficially they strongly resemble each other but their male genitalia would not indicate close relationship. Here is a place where the male genitalia may be of specific rather than generic value.

*Morrisonia evicta* Grt. Fig. 151A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—almost trigonal; Marginal spines—present; Corona—present; Protuberances—a very slender chitinous rod and a large curved strap; Editum—absent; Clavus—rounded; *Ædæagus*—without ornamentation; Vesica—without ornamentation.

*Xylomyges conspicillaris* Linn. Fig. 155A.

Uncus—slightly cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—truncate, not spinose; Marginal

spines—present; Corona—absent; Protuberances—an irregular chitinous ridge in a small rod, also a prominent curved hook; Editum—indicated; Clavus—produced; *Ædæagus*—without ornamentation; Vesica—with a row of teeth and an irregular hook.

*Himella fidelis* Grt. Fig. 159A.

Uncus—simple; Peniculus—absent; Scaphium and Subscaphium—absent; Harpe—truncated, with the edges bordered, some spines present; Marginal spines—absent; Corona—absent; Protuberances—a small chitinous projection bearing a short papilla provided with spines and a small pointed projection. There is also a very long chitinous rod ending in a small spine; Editum—absent; Clavus—rounded; *Ædæagus*—not ornamented; Vesica—not ornamented.

*Alysia specifica* Gn. Fig. 163A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—present; Protuberances—two flat straps turned out at their tips; Editum—absent; Clavus—rounded?; *Ædæagus*—.....; Vesica—.....

*Hyperopia jugifera* Dyar. (pi. B. & L.). Fig. 167A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a somewhat hooked shaped spine and a smaller curved chitinous protuberance; Editum—present; Clavus—rounded; *Ædæagus*—with one stout spine and two clusters of smaller spines. One cluster lies dorsad and the other laterad and on the opposite side from the stout spine; Vesica—without ornamentation.

*Nephelodes emmedonia* Cram. (*minians* Gn.). Fig. 171A.

Uncus—spoon shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded with pollex that bears two small spines at its tip. Spinose; Marginal spines—present; Corona—absent; Protuberances—a flat curved strap. The one on the right side longer. There is also another flat strap rounded

at its tip; Editum—present; Clavus—scobinated; *Ædœagus*—without ornamentation; Vesica—without ornamentation.

*Monostola asiatica* Alph. Fig. 175A.

Uncus—broad with tip truncated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, hardly spinose; Marginal spines—absent; Corona—present; Protuberances—an incurved organ roughened at its tip; Editum—present; Clavus—scobinated; *Ædœagus*—without ornamentation; Vesica—without ornamentation.

*Charaeas cespitis* Denn. & Schiff. Fig. 179A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—more or less truncated, spinose; Marginal spines—absent; Corona—absent; Protuberances—a flattened organ with its free edge curved; Editum—present; Clavus—rounded; *Ædœagus*—without ornamentation; Vesica—with a large cornutus and a roughened area.

*Haderonia subarschanica* Staud. Fig. 182A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose with a larger spine; Marginal spines—present; Corona—present; Protuberances—a weak chitinous bar and a small tubercle; Editum—absent; Clavus—rounded; *Ædœagus*—without ornamentation; Vesica—without ornamentation.

*Epineuronia popularis* Fab. Fig. 186A.

Uncus—spatulate; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked, hairy, and with a pollex; Marginal spines—present; Corona—absent; Protuberances—a flattened curved lobe which appears to be pointed when viewed from the side; Editum—present; Clavus—rounded; *Ædœagus*—a band of teeth near the orifice; Vesica—roughened.

*Acerra normalis* Grt. Fig. 190A.

Uncus—broad, diamond shaped at tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—few; Corona—absent; Protuberances—a small scobinated tubercle and a rough bar bent at an angle; Editum—absent;

Clavus—rounded; *Ædæagus*—orifice with two scobinated ridges; Vesica—not ornamented.

*Stretchia plusiaeformis* Hy. Edw. Fig. 194A.

Uncus—simple; Peniculus—present?; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a chitinous thickening and a slender curved bar; Editum—present; Clavus—rounded; *Ædæagus*—not ornamented; Vesica—scobinated and with a cornutus.

### Section B

#### Subsection Ia

There are five genotypes in this subsection and the male genitalia of all of them are figured. It has been previously stated that *Perigrappa* resembles both *Acerra* and *Stretchia*. If one compares their male genitalia with that of *Perigrappa*, no resemblance can be seen. On the other hand, *Eurypsiche* has been separated from *Meliana* on the bases of frons and other characters but the male genitalia of the two genotypes have much in common. Further morphological studies on related species are needed to clear up some of these points of relationship.

*Perigrappa i-cinctum* Denn. & Schiff. Fig. 198A.

Uncus—broad, diamond tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose with one tip produced forming a protuberance which bears a tuft of marginal spines; Marginal spines—present; Corona—absent; Protuberances—a very small projection bearing a few stiff bristles, and a curved strap which may or may not be roughened along one edge; Editum—present; Clavus—rounded; *Ædæagus*—without ornamentation; Vesica—without ornamentation.

*Xylomania hiemalis* Grt. Fig. 202A.

Uncus—a knobbed tongue; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—few; Corona—indicated; Protuberances—a very small chitinous spine and also another curved spine—Editum—present; Clavus—rounded; *Ædæagus*—not ornamented; Vesica—with a scobinated ridge and two small spines.



*Engelhardtia ursina* Smith. Fig. 206A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—broad, flattened at its apex with an indication of a pollex, not spinose; Marginal spines—absent; Corona—absent; Protuberances—a chitinous hook hardly free, and a curved spine; Editum—present; Clavus—rounded; *Ædæagus*—not ornamented; Vesica—with cornutus.

*Lasiestra phoca* Moschl. Fig. 210A.

Uncus—tongue shaped; Peniculus—.....; Scaphium and Subscaphium—absent; Harpe—rounded; Marginal spines—few; Corona—present; Protuberances—a curved claw turned inward, and a shorter curved bar turned outward; Editum—absent; Clavus—rounded, almost produced; *Ædæagus*—not ornamented; Vesica—with two small cornuti.

*Eurypsyche similis* Butler. Fig. 214A.

Uncus—tongue shaped; Peniculus—present ?; Scaphium and Subscaphium—absent; Harpe—rounded, spinose, slightly pointed; Marginal spines—absent ?; Corona—absent; Protuberances—three curved processes; Editum—.....; Clavus—rounded; *Ædæagus*—not ornamented; Vesica—with a row of very large teeth.

## Subsection Ib

There are seven genotypes in this section one of which—*Scotogramma submarina* Grt.—is not figured on the plates of male genitalia. Only two of the remaining six show any resemblance. There are *Barathra albicolon* Ochs. and *Neuria reticulata* Linn.

*Cardepia irrisor* Ersch. Fig. 218A.

Uncus—spatulate; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent ?; Corona—present; Protuberances—a broad chitinous organ somewhat pointed at its tip; Editum—.....; Clavus—concave on one side, irregular on the other; *Ædæagus*—.....; Vesica—.....

*Trichocosmia inornata* Grt. Fig. 222A.

Uncus—spatulate; Peniculus—absent ?; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—present,

some of which are very stout; Corona—absent; Protuberances—a very slight fold near the apex of each harpe, and the right harpe bears a club shaped organ with small teeth at its tip; Editum—absent; Clavus—more or less rounded; Ædœagus—bears a single spine; Vesica—spined.

*Barathra albicolon* Ochs. Fig. 226A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose; Marginal spines—present; Corona—present; Protuberances—a flat, slightly scobinated strap above which is a more slender curved organ; Editum—present; Clavus—produced; Ædœagus—orifice with a hook on one side, and a band of teeth; Vesica—with a band of teeth.

*Neuria reticulata* Vill. (griseo-reticulata Retzius). Fig. 242A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonal, spinose; Marginal spines—present; Corona—present; Protuberances—a chitinous flap, a ridge, and a small curved bar; Editum—present; Clavus—scobinated; Ædœagus—orifice with a hook; Vesica—with a band of small teeth.

*Dianthoecia carpophaga* Bork. Fig. 234A.

Uncus—simple; Peniculus—absent; Scaphium and Subscaphium—absent; Harpe—small, rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a small, flat lobe with rounded tip, and a chitinous fold; Editum—present; Clavus—rounded; Ædœagus—with two scobinated lobes, one on each side; Vesica—with a small bulbed cornutus.

*Sideridis evidens* Hub. Fig. 238A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few; Corona—present; Protuberances—a curved strap slightly rough at its tip; Editum—present; Clavus—produced; Ædœagus—not ornamented; Vesica—not ornamented.

#### Subsections IIa and IIb

In these two sections there are seven genotypes. The male genitalia of five of these are figured. The two not illustrated are

*Craterestra lucina* Druce, and *Discestra chartaria* Grt. All seven genotypes can be readily separated on the basis of their frons and antennæ and the genitalia of those which have been studied show enough differences to warrant their separation.

*Xanthopastes timais* Cram. Fig. 246A.

Uncus—large, bilobed, spinose; Peniculus—.....; Scaphium and Subscaphium—absent; Harpe—truncated; spinose; Marginal spines—absent; Corona—present; Protuberances—on the left harpe only a flat, rounded, spinose projection; Editum—.....; Clavus—rounded, very spinose; Ædæagus—not ornamented?; Vesica—with a cornutus and many small spines.

*Cea immacula* Grt. Fig. 266A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few present; Corona—absent; Protuberances—a strongly bent chitinous strap; Editum—present; Clavus—rounded; Ædæagus—the base provided with a long hook; Vesica—not ornamented.

*Trichoclea decepta* Grt. Fig. 8B.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a strap rounded at its tip, also a chitinous ridge hardly free and with a waved edge (two views are shown of this structure in the figure); Editum—absent; Clavus—produced, more on the right side. Both sides with bristles on the rounded portion; Ædæagus—scobinated on one side; Vesica—without ornamentation.

*Ichneutica ceraunias* Meyrick. Fig. 250A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—present; Protuberances—a flat, chitinous organ drawn to a point and bearing transverse ridges; Editum—absent; Clavus—rounded; Ædæagus—not ornamented; vesica—not ornamented.

*Miodera stigmata* Smith. Fig. 262A.

Uncus—slender, diamond tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, not spinose; Mar-

ginal spines—absent; Corona—present; Protuberances—a broad, flat hook and a chitinous thickening hardly free at its tip; Editum—present; Clavus—rounded; *Ædæagus*—orifice with a single cornutus; Vesica—with a large cornutus ?.

#### ACKNOWLEDGMENTS

This work could not have been carried on without the aid of many who so kindly offered their time, suggestions, or material for study. Material for dissection and examination was obtained from Dr. F. E. Lutz and Mr. Frank E. Watson of the American Museum of Natural History in New York. The late Dr. William Barnes and Dr. Harrison Dyar furnished many specimens for study. Later Drs. Schaus and Benjamin permitted the writer to study material in the United States Museum. My visits to the National Museum have always been both profitable and pleasant thanks to the cordial reception I have received from the last two named gentlemen.

Specimens from Vancouver Island and British Columbia were furnished by Mr. George O. Day, while those from New Zealand came through Mr. George V. Hudson. The Australian species included in this paper were kindly donated by Dr. Jefferies Turner.

Through the kindness of Dr. T. J. Headlee of Rutgers University, the writer was able to examine some of John B. Smith's types which are in the college collection.

Last but not least credit is due to the staff of the entomological department of the Massachusetts State College where the work was begun. Of this group I wish to mention in particular Dr. Henry T. Fernald. Access to his very fine entomological library placed at the disposal of the writer many scarce volumes which made the work easier and the progress more rapid.

#### CONCLUSION

The reader may notice that there are a few *Hadenine* genotypes which are not mentioned in this paper. The omissions are due to the lack of material. These omissions are few in number and it seemed best not to delay publication on their account, especially since there was no assurance that the gaps could be quickly filled.



These needed species, when available, will form the basis for a short supplement to this article. *Polia* has been omitted because its type, *flavicincta*, is not a *Hadenine* and therefore cannot replace either *Mamestra* or *Hadena*.

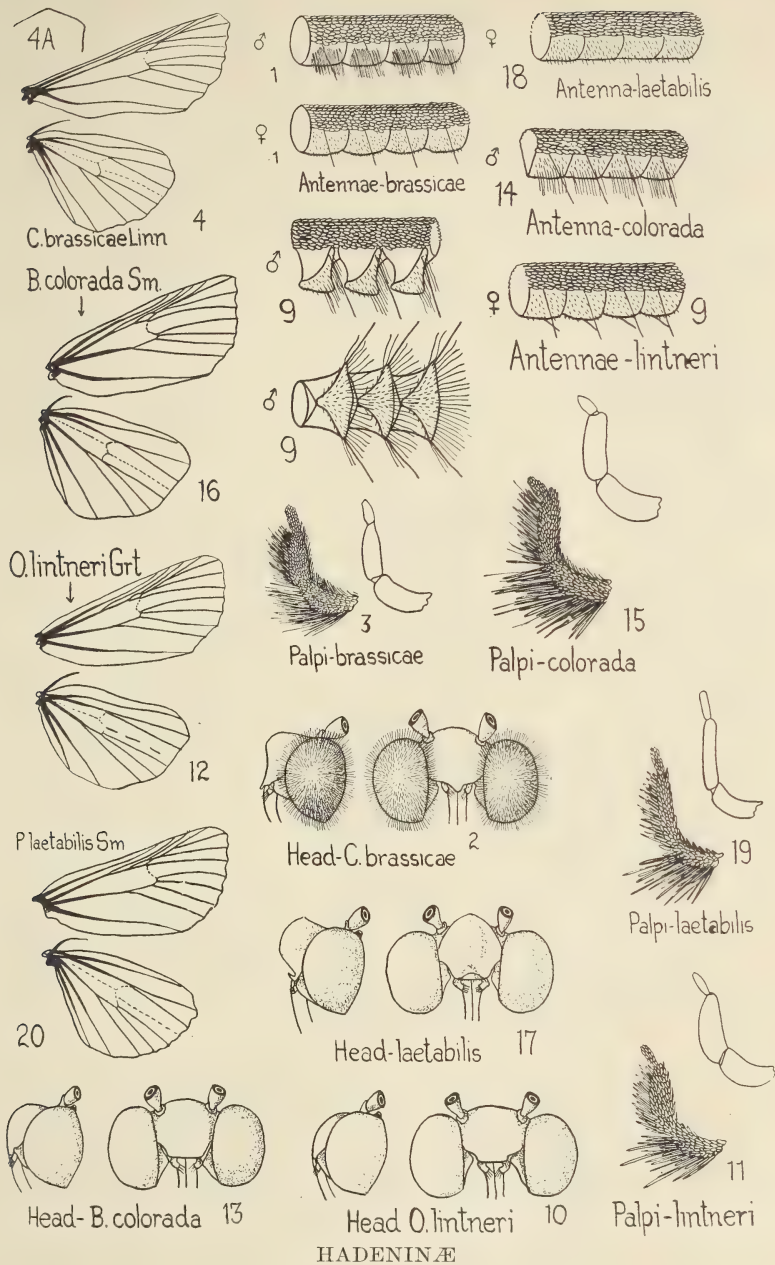
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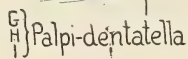
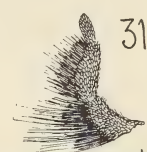
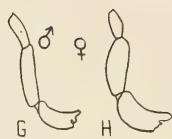
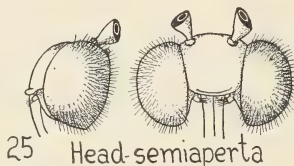
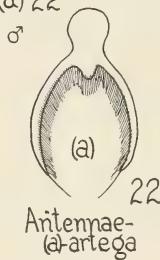
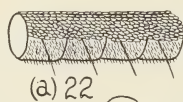
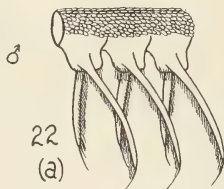
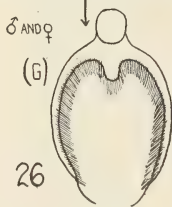
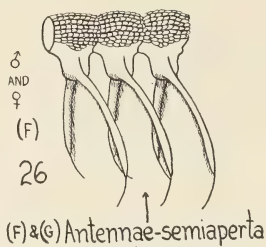
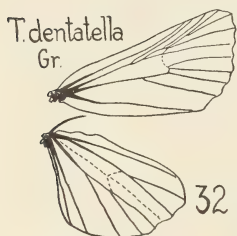
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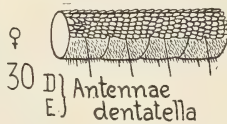
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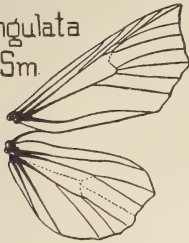
Palpi-semiaperta





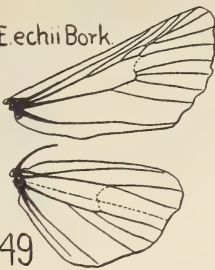
Pangulata  
Sm.

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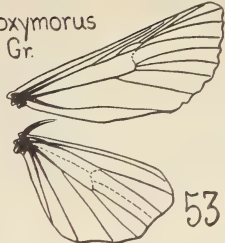
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A.oxymorus  
Gr.

53



Prudis Wlk

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H.purpurigera  
Gn

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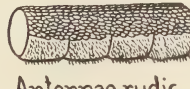
♂

38



♀

38



Antennae-rudis

♂

(F)

34



♂

(G)

34



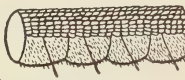
♂

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♀

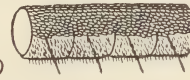
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Antennae-echii

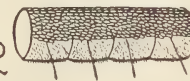
♂

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♀

42



Antennae-purpurigera

♂



34



(D)

34

(D),(E),(F),(G) Antennae angulata

♀

51

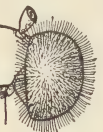


♂

51



Antennae-oxymorus



Head-purpurigera

41



Head-rudis

37

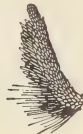


Head-angulata

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Palpi-purpurigera



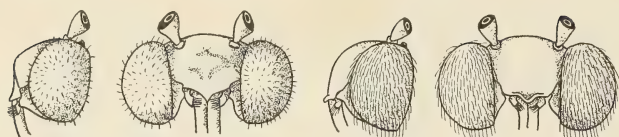
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Palpi-angulata



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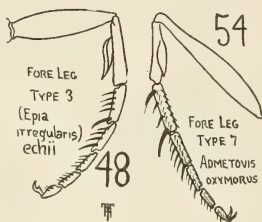
Head-oxymorus 50



Palpi-echii 47



Palpi-oxymorus 52



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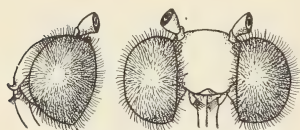
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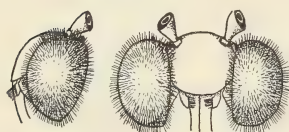


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♂ 67



♀ 70

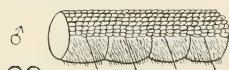


♂ 70

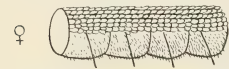


♀ 70

Antennae-picta



♂ 82



♀ 82

Antennae-niveiguttata



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Palpi-niveiguttata



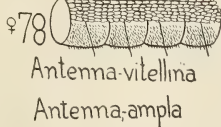
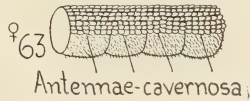
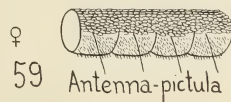
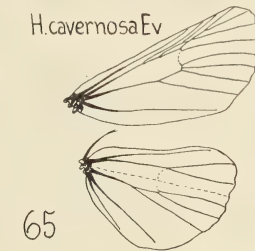
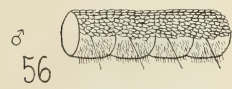
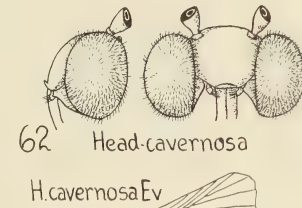
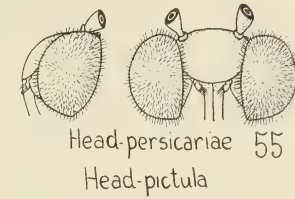
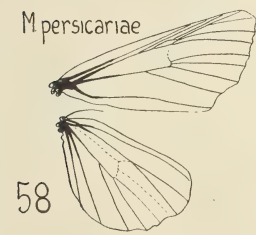
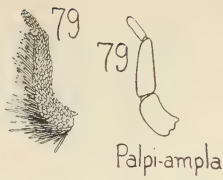
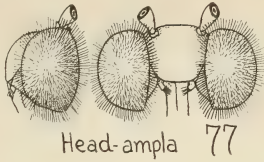
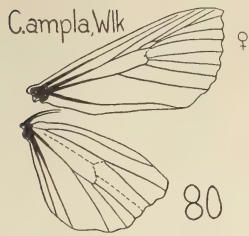
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Palpi-picta

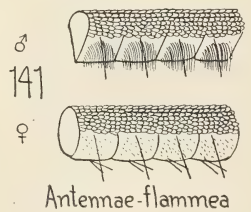
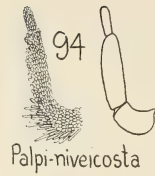
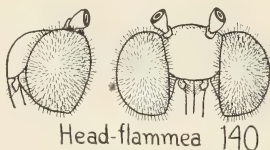
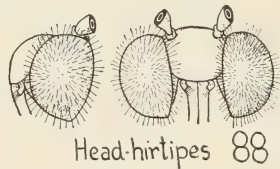
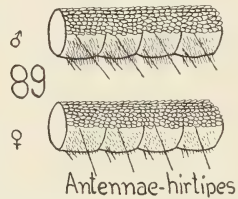
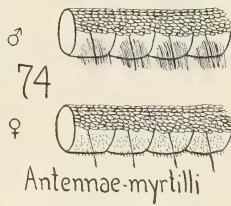
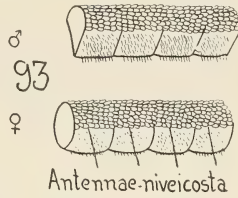
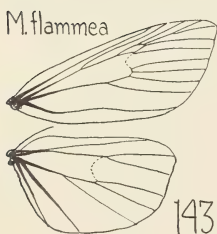
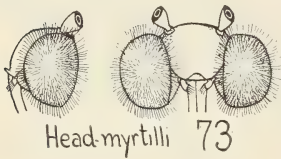
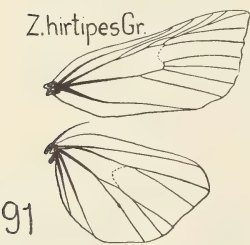
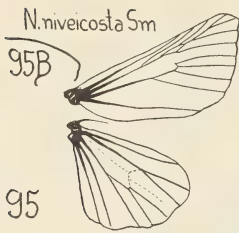


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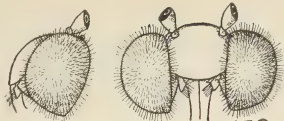
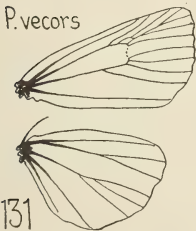
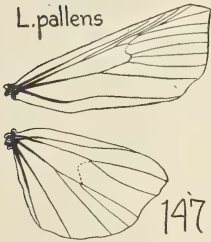
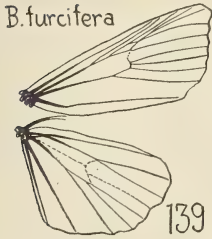
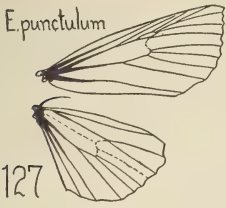
Palpi-albipuncta







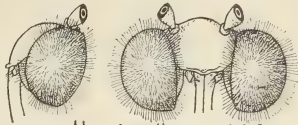




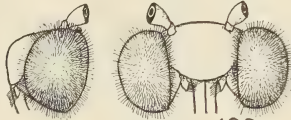
Head-moesta

Head-punctulum

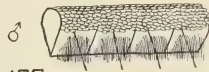
Head-furcifera



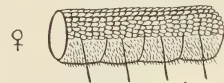
Head-pallens



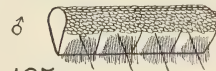
Head-vecors



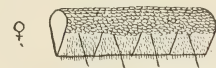
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Antennae-moesta



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Antennae-punctulum



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Antennae-vecors



Palpi-punctulum



Palpi-moesta



Palpi-pallens



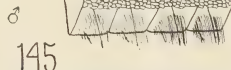
Palpi-furcifera



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Antenna-furcifera



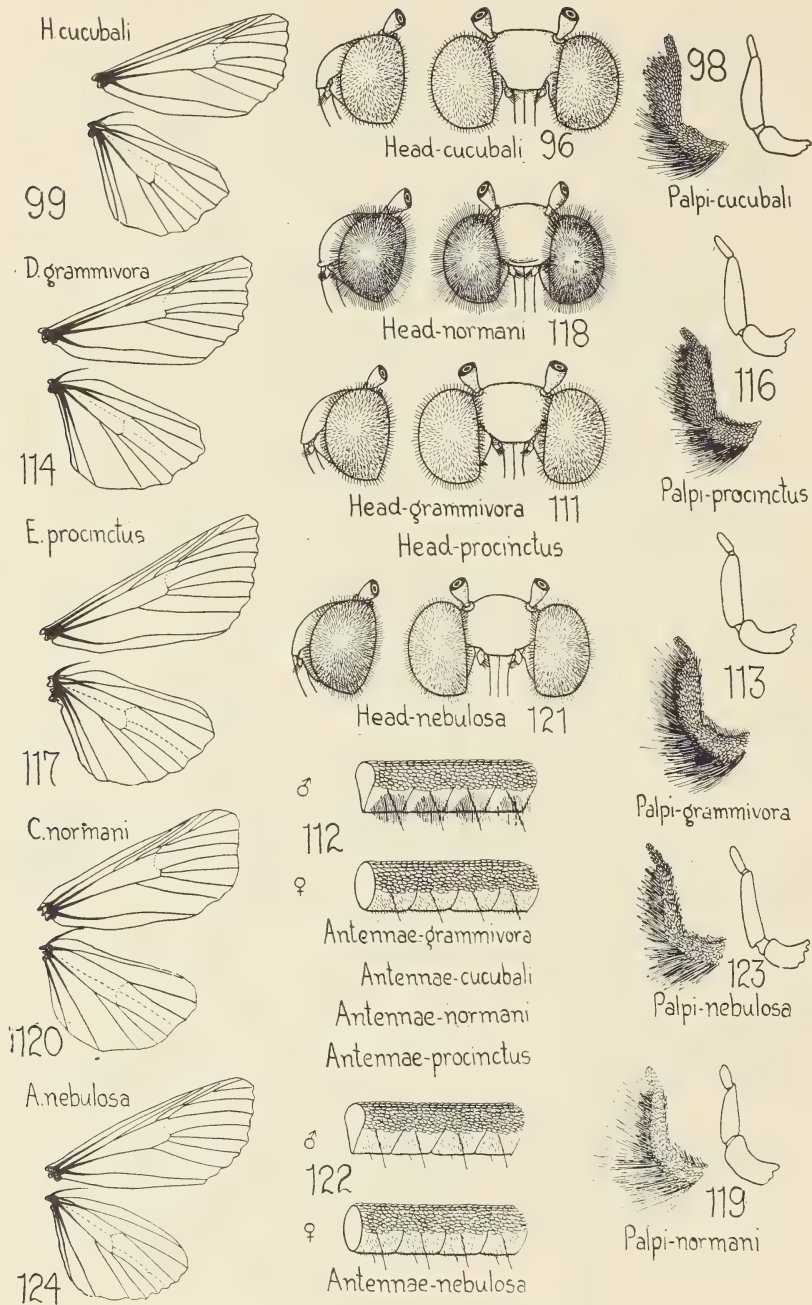
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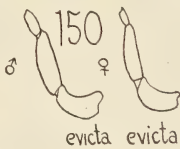
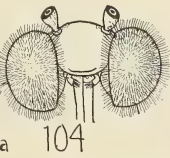
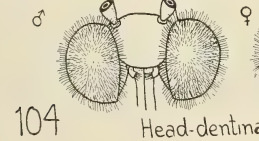
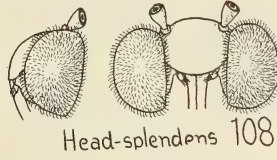
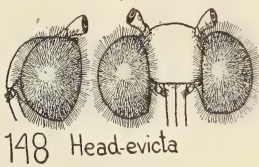
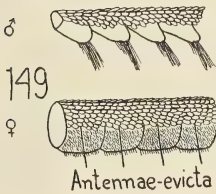
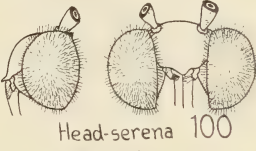
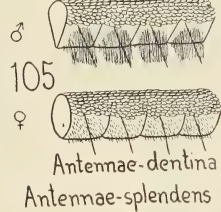
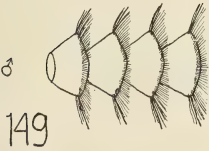
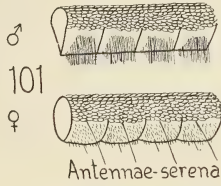
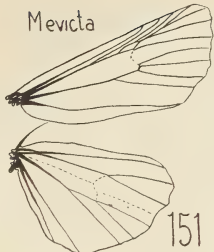
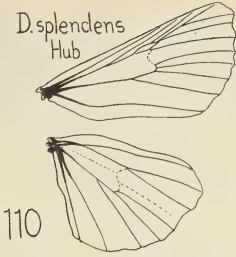


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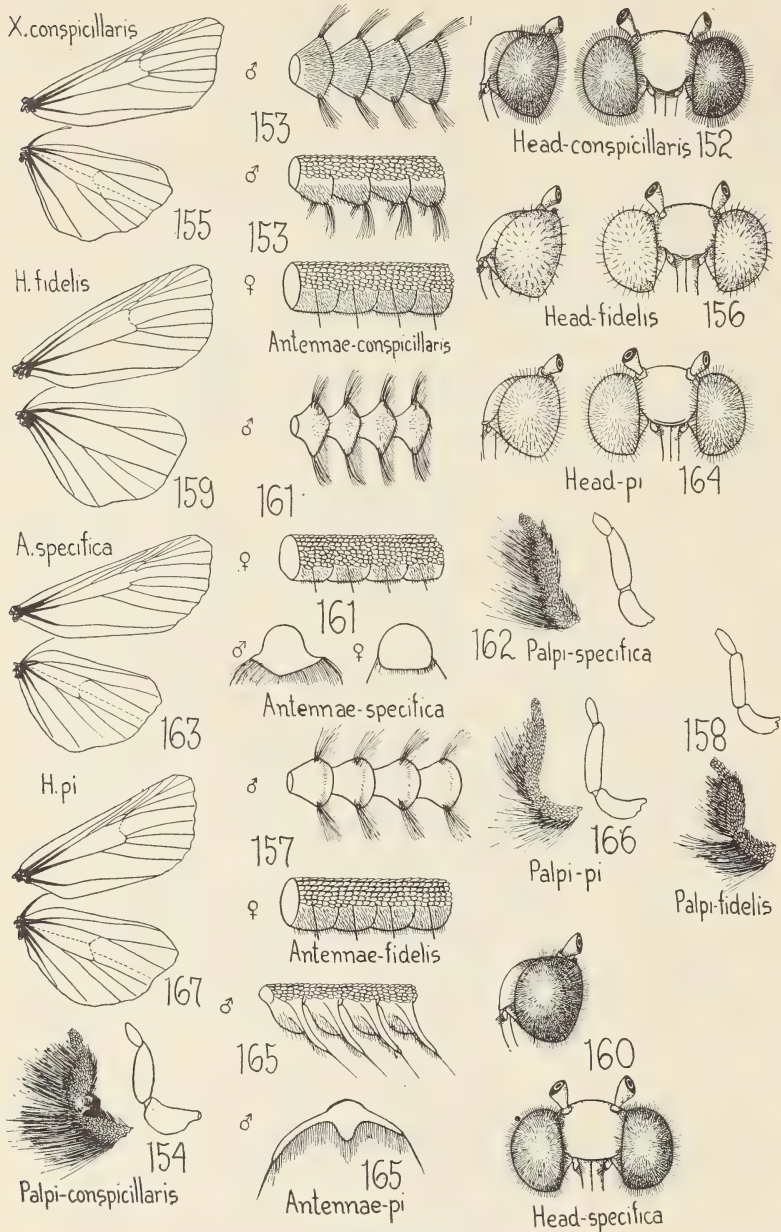


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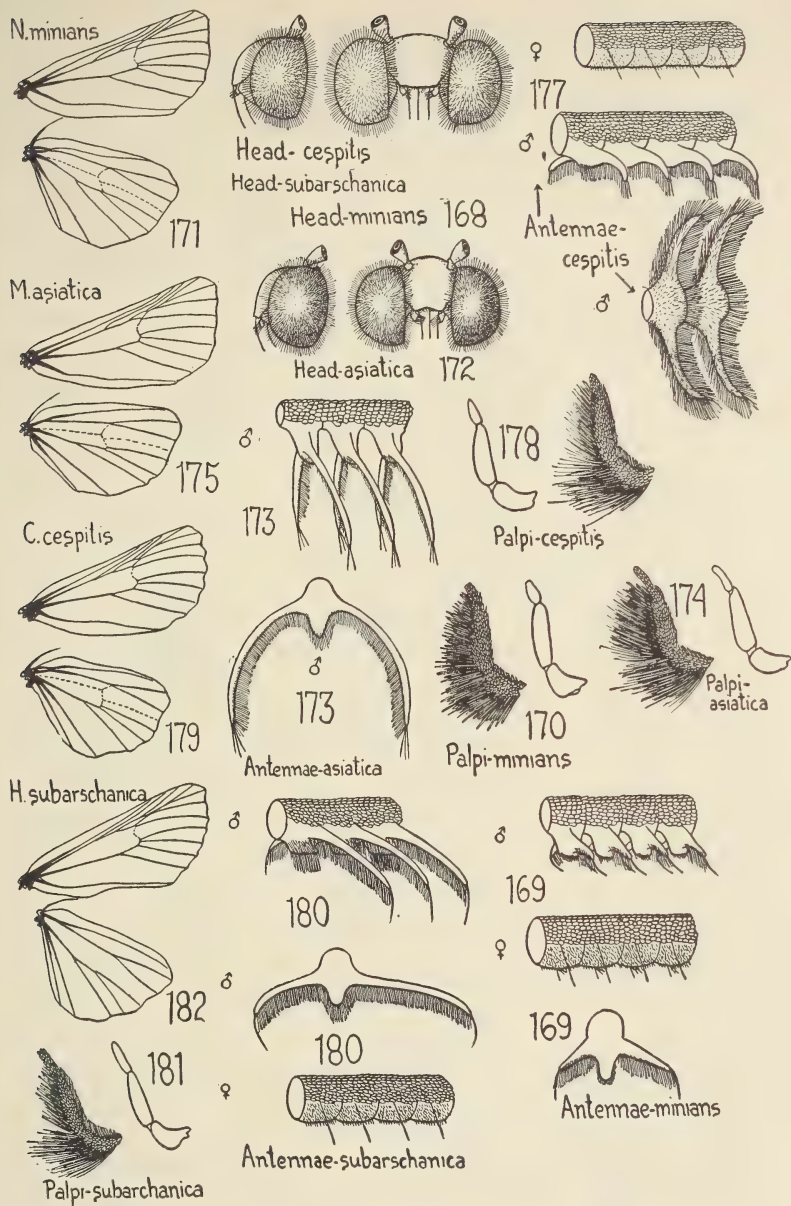


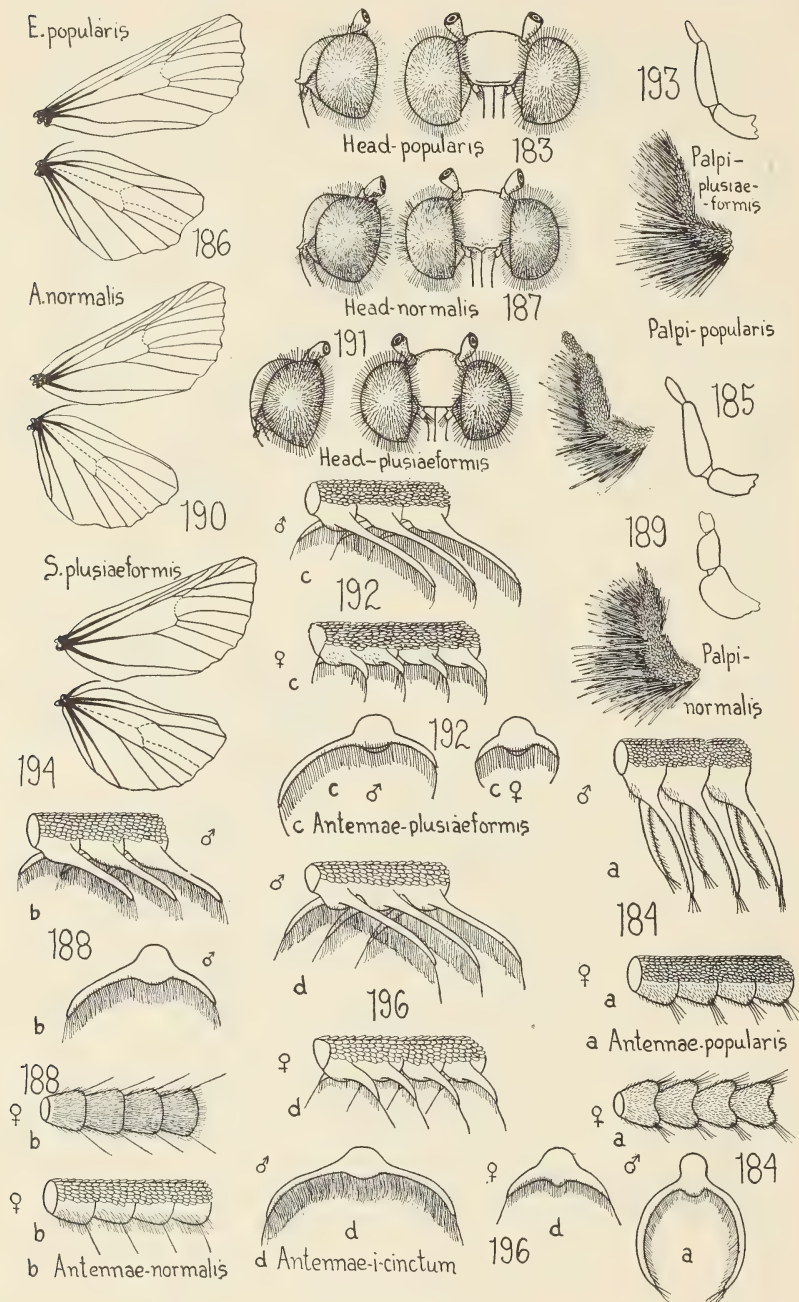


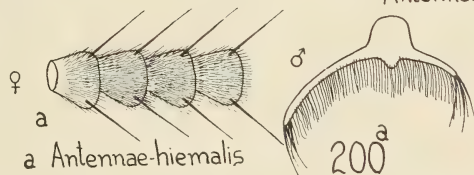
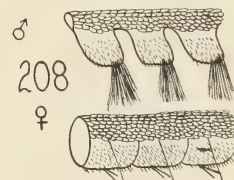
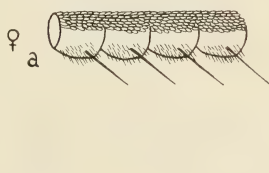
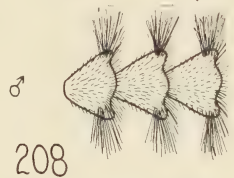
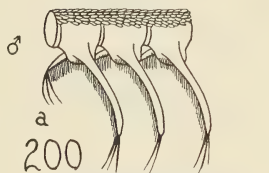
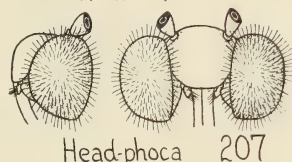
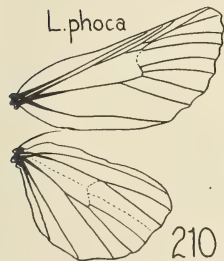
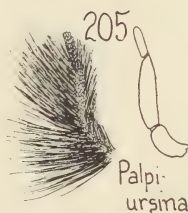
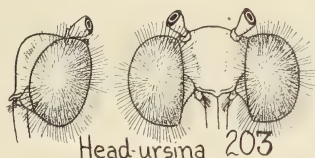
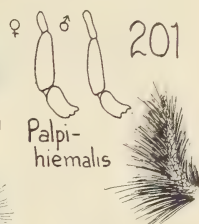
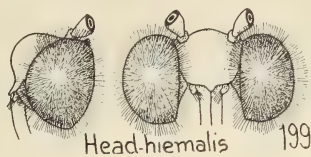
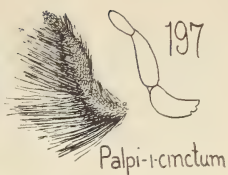
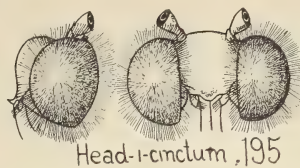
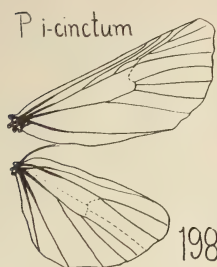
HADENINÆ





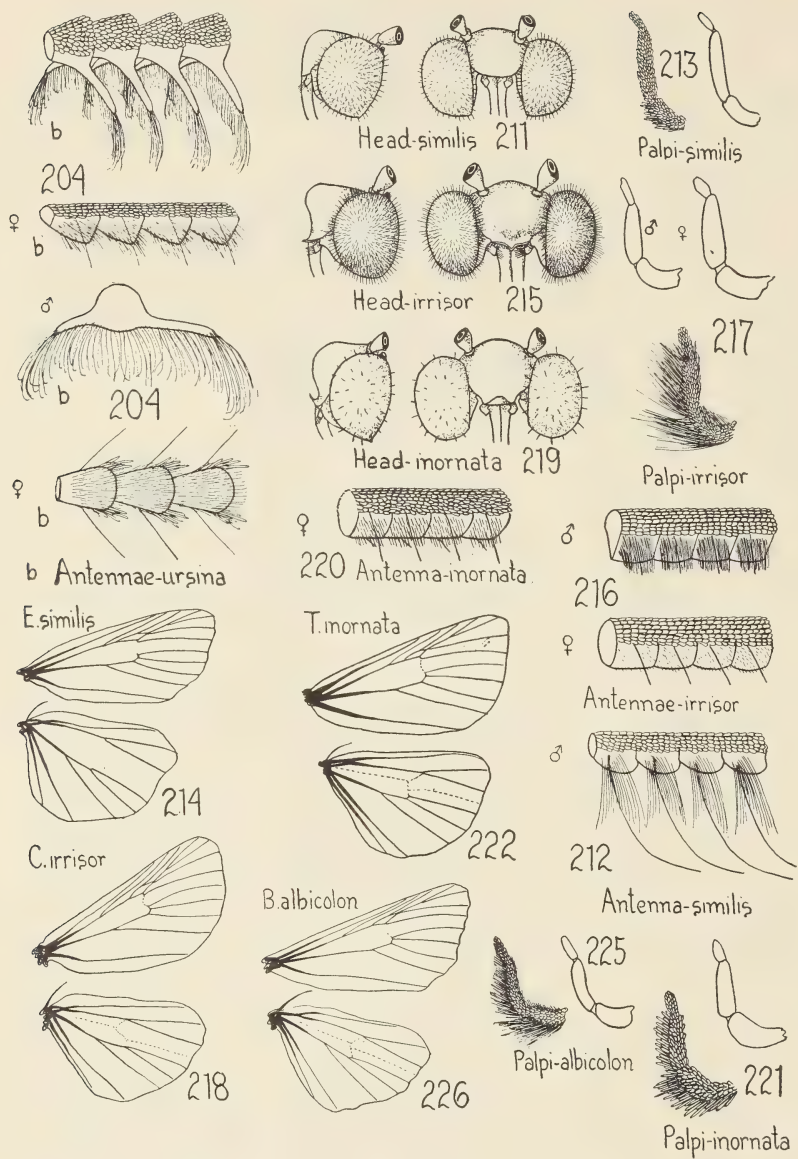




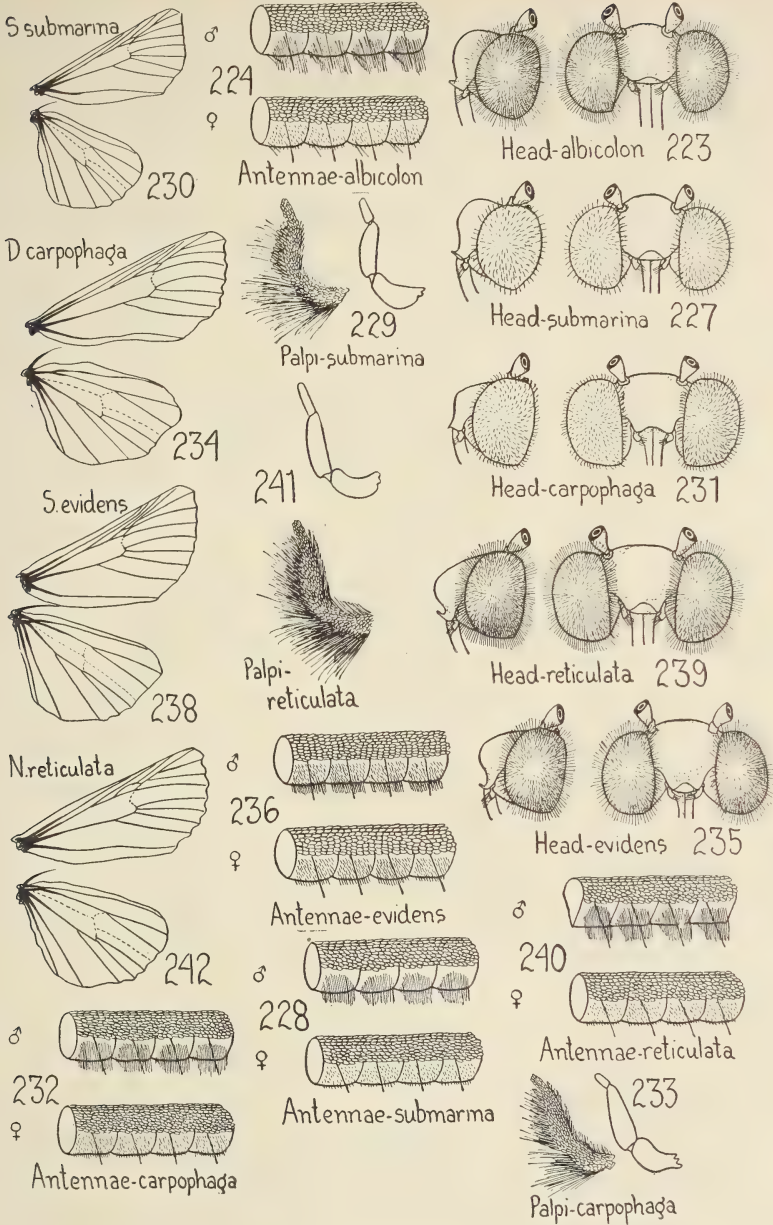


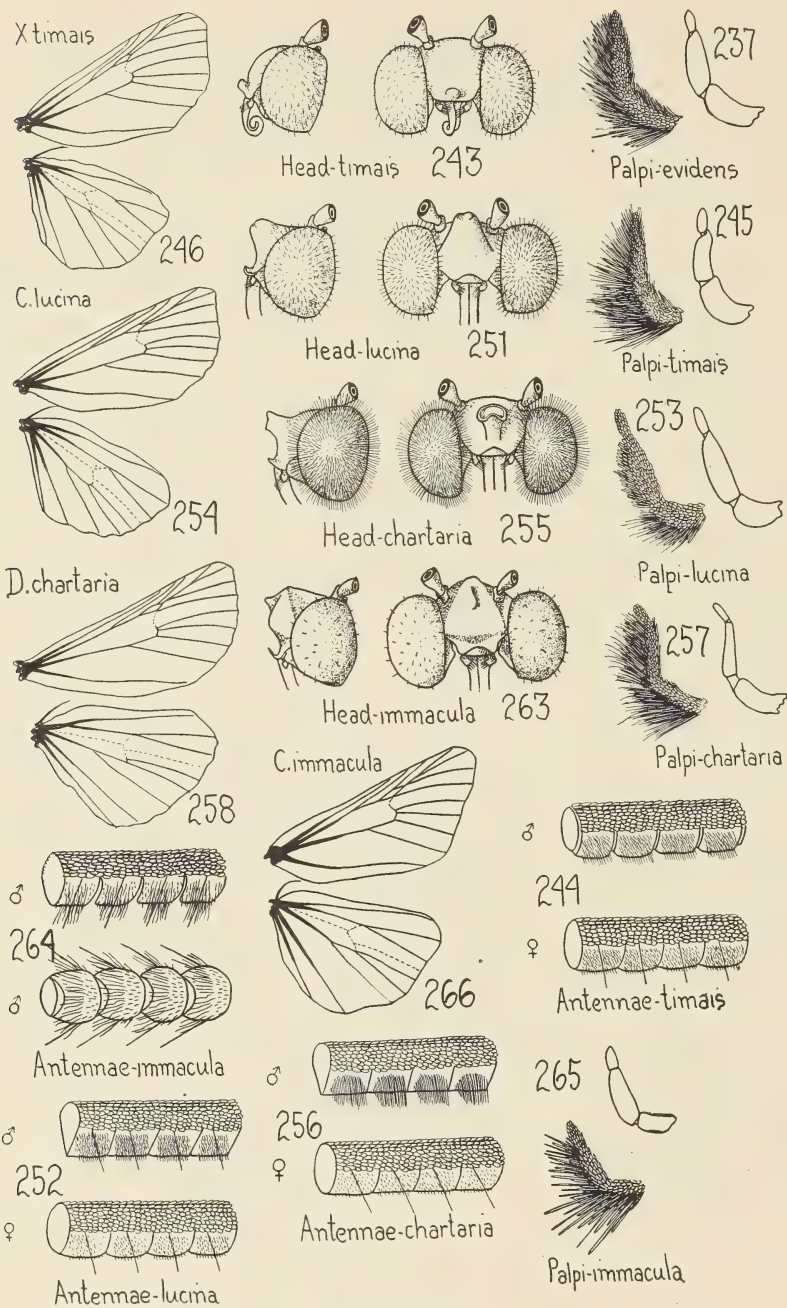
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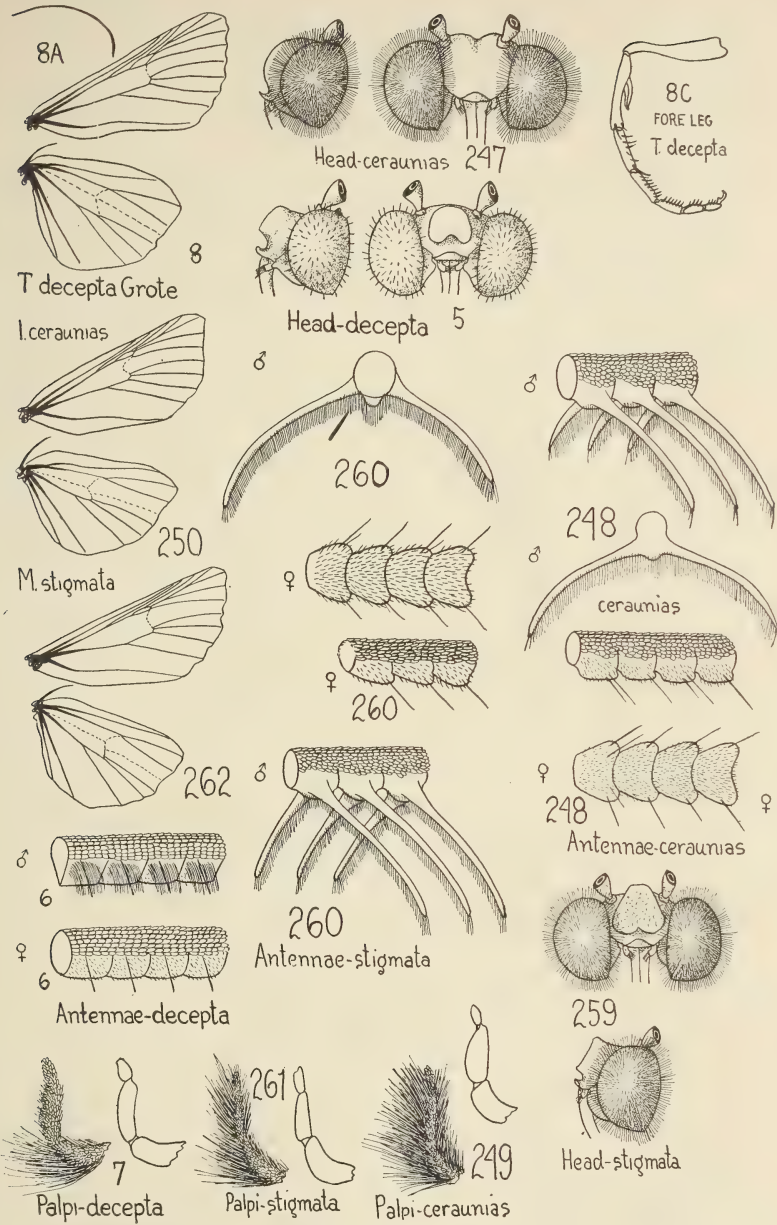




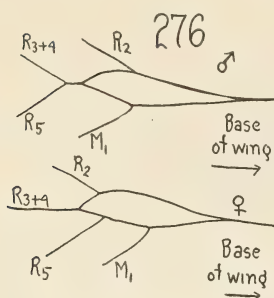




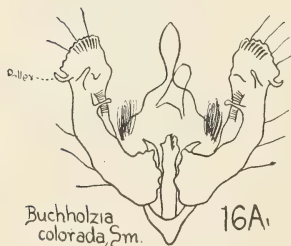
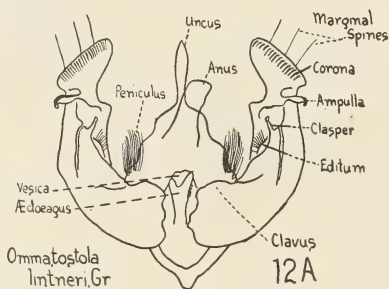
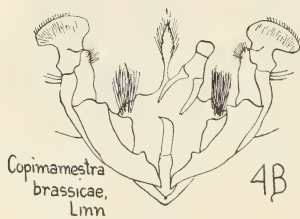
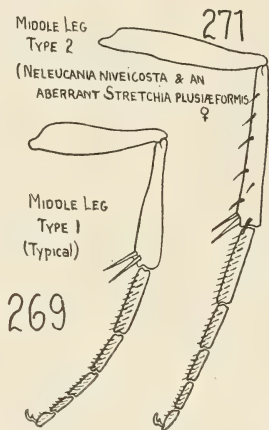
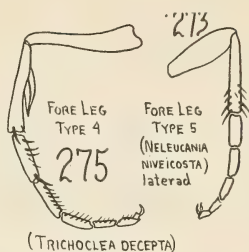
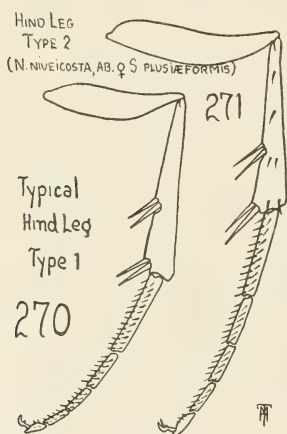




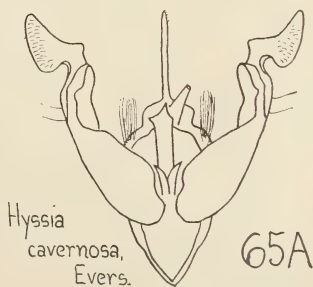
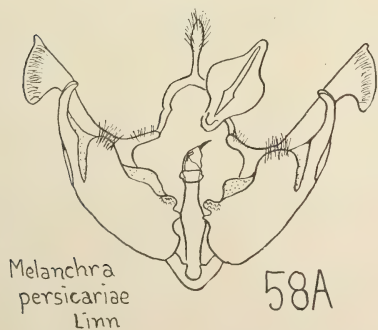
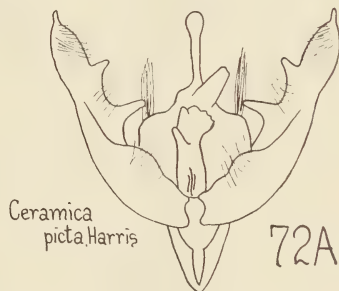
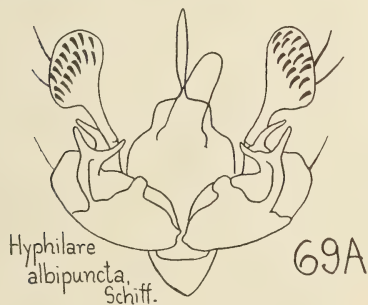
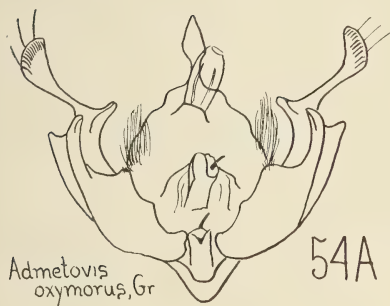
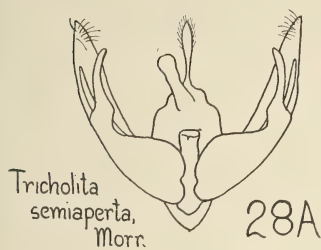
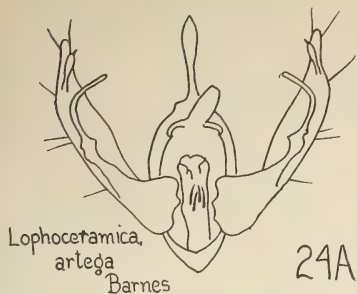
HADENINÆ



Variations in the areole  
of *Trichoclea decepta*

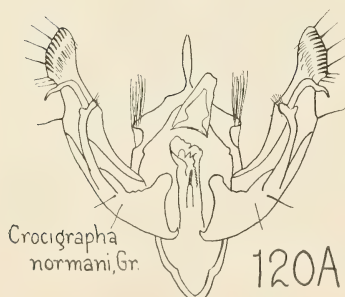
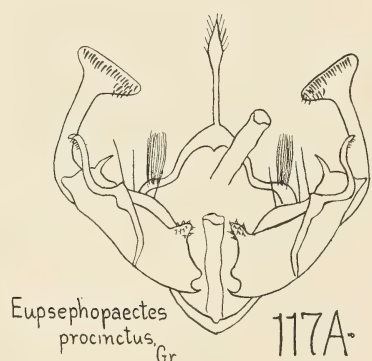
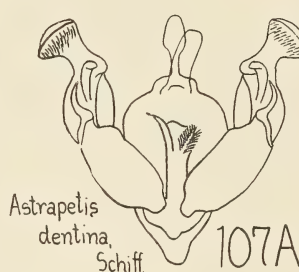
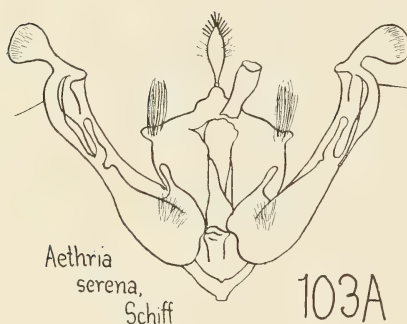
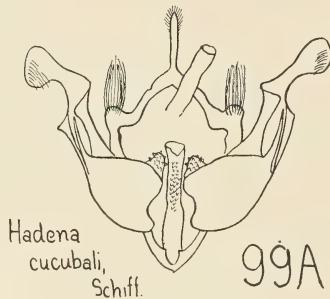
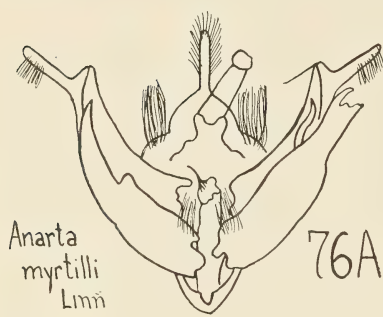
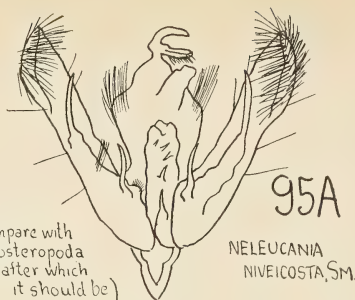






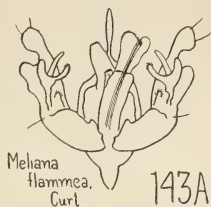


(compare with  
Zosteropoda  
after which  
it should be  
placed)





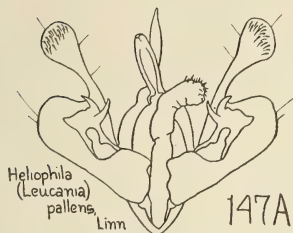
131A



143A



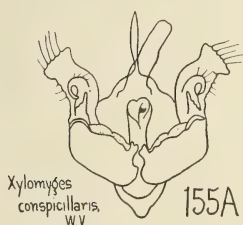
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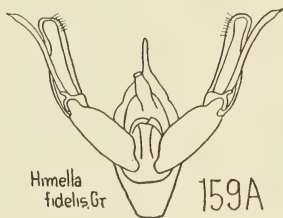
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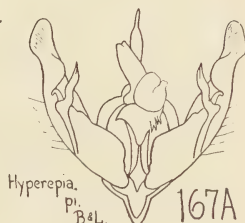
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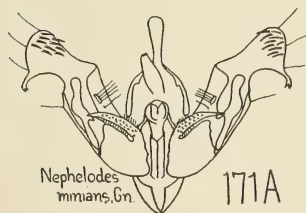
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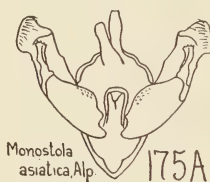
159A



167A



171A



175A

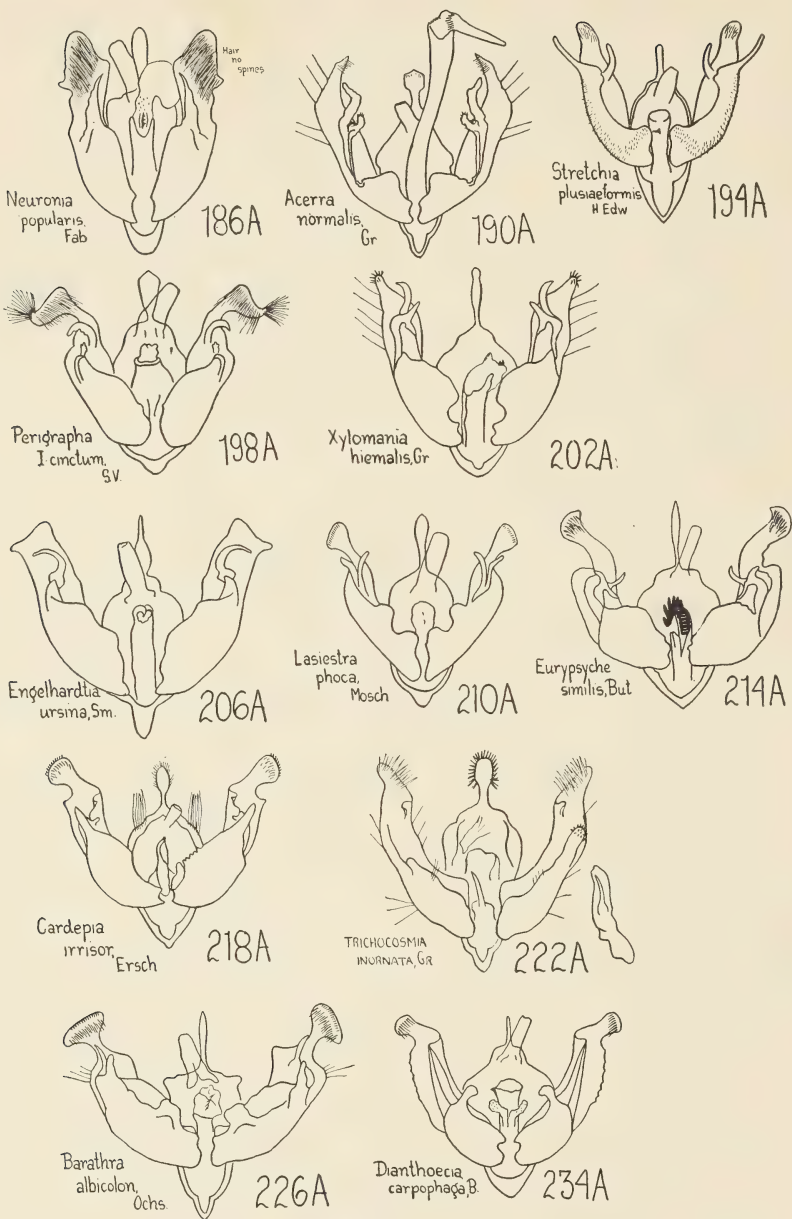


182A

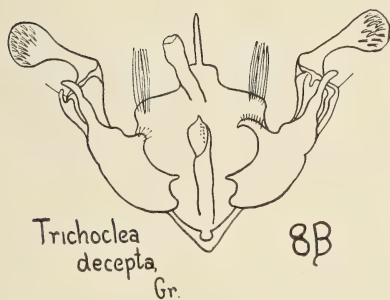
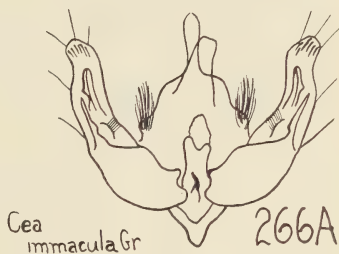
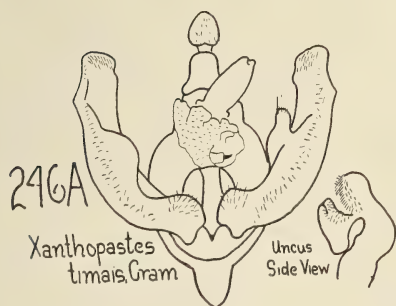
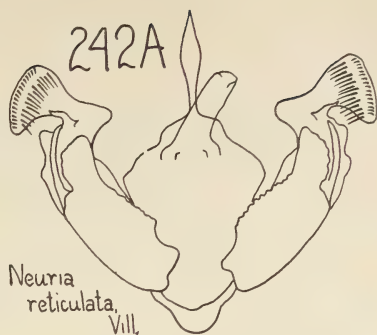
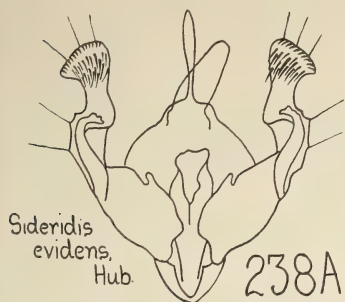


179A

HADENINÆ







## A SECOND RECORD OF THE DRAGONFLY NEUROCORDULIA VIRGINIENSIS

BY WILLIAM T. DAVIS, STATEN ISLAND, N. Y.

On June 21, 1919, a single female *Neurocordulia* of unknown species was collected close to the James River in Buckingham County, Virginia. No additional specimens were found though the locality was visited in subsequent years, so the insect was finally described in the "Bulletin of the Brooklyn Entomological Society," Vol. 22, June, 1927, under the name of *Neurocordulia virginensis* Davis. Later it was again figured and compared with the type of *Neurocordulia clara* Muttkowski, in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, Vol. 37, December, 1929.

On July 23, 1934, Mr. A. Earl Pritchard sent me a female *Neurocordulia* from his collection which he had correctly identified as *virginensis* and which was compared with the type from Virginia before its return to Mr. Pritchard. He has lately given me the data connected with the specimen and writes as follows: "The single female *virginensis* was taken near Broken Bow, Oklahoma, in the southeastern corner of the state, June 17, 1934, by John Standcavish. The specimen was at some rapids at a wide part of Mountain Fork River, at dusk, in company with *Platycordulia xanthosoma* Williamson. The flight of the crepuscular dragonflies is so irregular together with the dim light that selective collecting is impossible."

This is but the second specimen of this evidently rare dragonfly to be recorded in about seventeen years.

## THE CRIMINAL PROSECUTION OF INSECTS

BY HARRY B. WEISS

In the November, 1926, issue of *Entomological News*, I wrote a little article entitled "Insects as Litigants." During the meantime, I came into the possession of a copy of "The Criminal Prosecution and Capital Punishment of Animals," by E. P. Evans, whose book is an expansion of two essays that appeared in "The Atlantic Monthly" for August and September, 1884. As insects are among the animals mentioned by Mr. Evans, and as entomologists, for the most part, are unfamiliar with this phase of historical entomology, it is believed that the present summary of Mr. Evans' account, insofar as it relates to insects, will be of interest. Mr. Evans' book was published in London in 1906 and has been out of print for many years.

Students of the history of jurisprudence have long been familiar with the early capital punishments imposed upon pigs, cows, horses and other domestic animals by secular courts, as a penalty for homicide, and with the judicial proceedings instituted by ecclesiastical courts against rats, mice and insects in order to prevent their ravages to crops, and to expel them from orchards and fields by exorcism and excommunication. Domestic animals could be arrested, tried, convicted and executed just like man, but as this was not possible in the case of insects, which were not subject to control by the civil authorities, or in fact by any human agency, the Church had to take them in hand and exercise its supernatural functions against them. This it did by resorting to "metaphysical aid." And so noxious insects were expelled or exterminated by sacerdotal conjuring and cursing. Nowadays it is customary to obtain large appropriations from Congress for this purpose. It was customary to bring some of the injurious insects to court and to put them to death while the malediction was being pronounced.

In explaining the reasons for the visitations of insect pests the Church sometimes said that they were sent by Satan, and at other times by God for the punishment of man's sins. In either case, relief was to be had only through the action of the Church.

The Council of Worms in 864 decreed that bees that had been responsible for stinging a man to death should be suffocated in their hive so that the honey would not be demoniacally tainted and unfit for food. The pastoral staff of St. Magnus was frequently carried in solemn processions, from 1685 to 1770, to such places as Lucerne, Zug and other places in Switzerland for the purpose of expelling and exterminating insects as well as rats and mice. And excommunications against insects could be purchased from Rome. At times the insects received advance warnings. Public processions were held in parishes and noxious insects were warned to stop their ravages under penalty of excommunication. Sometimes they were given a specified time, such as six days, in which to disappear.

In 1545, legal proceedings were started by the wine-growers of St. Julien against the weevil "*Rychites auratus*," which was injuring their vineyards, but instead of passing sentence upon the insects, the official issued a proclamation recommending public prayers. It was characteristic of such proclamations to carry a preamble like the following: "Inasmuch as God, the supreme author of all that exists, hath ordained that the earth should bring forth fruits and herbs (*animas vegetativas*), not solely for the sustenance of rational human beings, but likewise for the preservation and support of insects, which fly about on the surface of the soil, therefore it would be unbecoming to proceed with rashness and precipitance against the animals now actually accused and indicated; on the contrary, it would be more fitting for us to have recourse to the mercy of heaven and to implore pardon for our sins." This preamble was followed by instructions for conducting public prayers and in this particular case, the curate attested that the instructions were fully carried out and that the insects disappeared soon afterwards.

However thirty years later there was another outbreak of the species in question and the weevils were brought to trial. The documents recording the proceedings are preserved in the archives of St. Julien and they have been printed in the "*Mémoires de la Société Royale Académique de Savoie*." On April 13, 1587, the case was brought before "his most reverend lordship, the prince-bishop of Maurienne, or the reverend lord his vicar-general and



official," by the magistrates and proctors, François Amenet and Petremand Bertrand, who presented the following petition for the inhabitants of St. Julien:—"Formerly by virtue of divine services and earnest supplications the scourge and inordinate fury of the aforesaid animals did cease; now they have resumed their depredations and are doing incalculable injury. If the sins of men are the cause of this evil, it behoveth the representatives of Christ on earth to prescribe such measures as may be appropriate to appease the divine wrath. Wherefore we the afore-mentioned syndics, François Amenet and Petremand Bertrand, do appear anew (*ex integro*) and beseech the official, first to appoint another procurator and advocate for the insects in place of the deceased Pierre Falcon and Claude Morel, and secondly, to visit the grounds and observe the damage, and then to proceed with the excommunication." As a result of this request Antoine Filliol was appointed procurator for the insects and Pierre Rembaud the advocate for the insects. On May 30, both parties appeared before the official and the case was adjourned to June 6, when Mr. Rembaud answered the plaintiffs by presenting a statement showing that their action was not maintainable and that they should be nonsuited. He argued that his clients, were within their right, that they had not made themselves liable to excommunication since the lower animals were created before man and that it was the intention of the Creator to assure them suitable and sufficient means of support. After more in a similar vein, and after he said that it was absurd to invoke the authority of civil and canonical law against beasts that were subject only to natural law and their instinct, he asked that the complaint be dismissed.

The case was adjourned to June 12 and again to June 19, when Mr. Bertrand the prosecuting attorney presented a long reply of which the defendants' advocate demanded a copy for study. Another adjournment took place until June 26 and as this was a holiday, no business could be transacted until June 27, when the prosecuting attorney argued that although animals were created before man, they were intended to be subordinate to him and subject to his use. The lawyer for the insects made no reply to this, but merely said that he had not yet received the document ordered on June 19, and so the case was postponed until July 4.

Antoine Filliol at that time replied to the plaintiffs and said that his opposing counsel had not even attempted to disprove the contention that lower animals were subject only to natural law. Both parties appeared before the official of St. Jean-de-Maurienne on July 18. The procurator of the insects asked for the case to be closed and the plaintiffs debarred from introducing more irrelevant matter. The prosecuting lawyer asked for a new term which was granted. Meanwhile, because of the legal delays an attempt was made to adjust the trouble by compromise. On June 29, 1587, a public meeting was called for the purpose of considering the propriety of providing a feeding place for the insects, outside of the vineyards of St. Julien. A plot of ground was selected, the inhabitants reserving for themselves the right to pass through it and to make use of the spring water on it, also the right to work the ochre and other mineral-color mines on the plot, and to take refuge there in time of war. The assemblage voted for this and a conveyance was drawn up and properly witnessed and sealed. On July 24, the proceedings of the public meeting were submitted to the court by Mr. Bertrand, procurator for the plaintiffs, who remarked upon the generosity of the commune and prayed that the grant be accepted and the insects be ordered to vacate the vineyards and be forbidden to return on pain of excommunication. The procurator for the insects asked for a copy of the process-verbal and time for consideration. This was granted and the case was adjourned until "the first juridical day after the harvest vacation" which happened to be August 11, but again by the consent of both parties, it was postponed until August 20. At this time the movement of troops through the country interfered with the trial and it was postponed to August 27 and again to September 3, when Mr. Filliol stated that he could not accept the offer made by the plaintiffs because the plot of land was sterile and not fit for his insect clients to live upon. He moved for a dismissal of the action with costs to the complainants. Mr. Bertrand denied the correctness of Mr. Filliol's remarks and claimed that the land was admirably adapted for the insects, being full of trees and shrubs. He also insisted upon a settlement in his favor.

Thereupon the official took the briefs of both parties and reserved his decision. He then appointed experts to examine the

plot of ground and to submit a written report upon its fitness to support the insects.

After so much deliberation, it is too bad that the final decision is doubtful to us because the last page of the record was destroyed by rats or insects. Various items of expense were incurred during the trial, such as fees for clerical and legal services, and for the experts. It is of interest to note that during the trial, which was conducted with all seriousness, there was no question by either side of the right of the insects to an adequate type of support suited to their nature. Nowadays it is not believed that such a right would be recognized at all with respect to insects. In addition, during the progress of the trial, no one, apparently, had any doubts about the power of the Church, by virtue of its commands, to compel the insects to stop their ravages or to move to another place. Without such a belief in the Church, the whole trial would have lacked dignity and seriousness. In insect prosecutions the lawyers for the defense always made a strong point in declaring that the insects were sent to punish people for their sins and any attempt to destroy the agents of God would be displeasing to the Almighty. Under such circumstances, the best procedure was to repent and to pray to God to remove the instrument of punishment.

As a matter of fact, insects were not really excommunicated but more properly anathematized. Insects were not taxable members of the community, and excommunication implies the exclusion from the communion of the church and from other advantages related thereto. It is one of the results of an anathema, but it is limited to members of a religious body to which insects do not belong. Anathematization was also justified on the ground that the lower animals, including insects, being emissaries of Satan, it was right and proper for them to be cursed. Some early authorities believed that the anathema should not be pronounced against the animals as such, but inferentially against the devil who made use of such animals. However, not all animals were looked upon as bad, and in "The Book of King Mode and Queen Reason," printed in 1486, animals were divided into two groups, "sweet beasts" and "stenchy beasts." Near the end of the ninth century the country around Rome was visited by a plague of "locusts" and although millions were destroyed by the peasants,

more millions remained. Eventually Pope Stephen VI, prepared large volumes of holy water with which the whole country was sprinkled, whereupon the insects disappeared. The formula used in consecrating the water implied the diabolical character of the insects against which it was directed.

Various early accounts record the effectiveness of anathemas and bans against insects by the Church. For example, during the latter half of the fifteenth century, a plague of "locusts" threatened the province of Mantua in northern Italy. The insects were dispersed by excommunication. In 1338 "locusts" started to wreck the agricultural scenery around Botzen in the Tyrol. Proceedings were therefore started against them before the ecclesiastical court at Kaltern, ten miles south of Botzen, and the parish priest proceeded against them in a solemn ceremony of anathematization. Because of the sins of the people and their delinquency in the payment of tithes, the insects, for a time, resisted the power of the church, but finally disappeared.

There was a regular order to be followed for actions against insects, involving pleas, replications, rejoinders and decisions. On both sides the pleadings were saturated with Latin quotations, classical allusions and erudition. The pleas were patchworks of rhetoric, legal lore and literary affectation.

In 1478 a species of *Bruchus* destructive to crops was prosecuted and anathematized in Switzerland, the trial being conducted before the Bishop of Lausanne. First a parish priest delivered a long admonition from a Bernese pulpit relative to the injury done by the beetle or "inger," as it was called, and of the suffering it caused, then the mayor and common council were approached and asked to devise ways for relief. They held a conference with the Bishop of Lausanne, who issued a mandate enjoining the insect from committing further depredations. In this mandate, the bishop urged the people to pray and then he commanded the insects, of which he said there were none in Noah's ark at the time of the deluge, to depart within six days, from the fields where they were doing their damage. If for some reason they did not see fit to depart, they were supposed to appear on the sixth day after the issuance of the order, at Wiffisburg, there to justify themselves through their advocate before His Grace the Bishop of Lausanne.



There is no further record of what happened in this particular case. No doubt it was postponed on account of a technicality, as this was a common occurrence. However, a continuation of this case or a new one happened in May 1479 with the same insect. At that time the mayor and common council of Berne sent copies of the monitorium issued by the Bishop of Lausanne to their representative for distribution to the priests of the afflicted parishes so that it might be made known from their pulpits. About a week later, on May 15, the same authorities asked the Bishop of Lausanne for new instructions and urged immediate action. Apparently the insects were doing more damage and an anathema was needed at once.

After the appointed time had expired, with the insects ignoring everyone and everything, the mayor and common council of Berne issued a document giving Mr. Thüning Fricker the power of attorney to prosecute the case. This was on May 22, 1479. The trial began a few days later and ended on May 29. In this particular case, the usual legal delays, were somehow avoided. The sentence of the court which banned and exorcised the insects, was received with great joy by the people, but nothing came of it because of the sins of the people, and God permitted the "inger" to remain as a punishment until the people repented of their wickedness and gave evidence of their love to him by giving, to the Church, tithes of what the "inger" had not destroyed.

In the malediction issued by the priest, the "inger" was characterized as a species not in Noah's ark, so that there would be no impropriety in having the Church of God curse it. It would not have been proper to curse creatures that God had made and pronounced good and which he had taken pains to preserve from destruction by the deluge.

On June 26, 1659, Capt. J. B. Pestalozzi, appeared before commissioner Hartmann Planta, on behalf of the communes of Chiavenna, Mese, Gordona, Prada, and Samolico, and made a complaint about certain caterpillars, demanding that they should be summoned to appear in court in order to have a curator and defender appointed for them, to answer to the plaintiffs. This was done, a summons was issued, copies were posted in the forests and the advocate of the insects was ordered to appear in court on

behalf of his clients which were charged with trespassing upon fields, gardens and orchards where they did great damage, instead of remaining in the forests where they belonged. A trial was held and a definite place of abode was to be assigned to them. Here the record ends. The court recognized the right of the caterpillars to life, liberty and the pursuit of happiness, provided the exercise of such a right did not infringe upon the happiness of man "to whom the lower animals are subject." Other extant records involving such ecclesiastical acts as have been noted, refer to termites, gadflies, and other insects. Peasant communities were always willing to ward off insect devastations at the expense of their neighbors. In some cases the insects were notified verbally that better entertainment was to be had at another village.

In closing, a weak survival of ecclesiastical excommunication, that existed in these United States in 1888, may be noted. Mr. W. W. Newell in "The Journal of American Folk-Lore" (Jan.-Mar., 1892); records a letter that was written to rats in order to induce them to quit certain premises. This letter was rubbed with grease and stuffed into the runs of the rats so that it would not be overlooked. This particular letter was dated, "Maine, Oct. 31, 1888" and addressed to "Messrs. Rats and Co." The author began by expressing deep interest in the welfare of the rats, as well as concern lest they find their winter quarters in No. 1, Seaview Street, uncomfortable and with little food, since it was only a summer residence. He suggested that they move to No. 6 Incubator Street where they would be much happier. Here they could live in a cellar well stocked with vegetables and they would also have easy access to a barn containing grain. The writer concluded by advising the rats that no harm would come to them if they took his advice. But if they didn't he would use "Rough on Rats" against them.

## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF MAY 5, 1936

A regular meeting of the Society was held on May 5, 1936, in the American Museum of Natural History; President Ruckes in the chair with thirty-five members and forty-six visitors present.

Dr. Klots announced that the next meeting would be given over to a discussion of notes by members and summer collecting plans.

Upon the suggestion that there be a field trip, Dr. Ruckes appointed a committee composed of Messrs. Nicolay and Richard and Miss Clausen to draw up plans for field meetings.

Mr. W. U. Doyle of 176 Undercliff Ave., Edgewater, New Jersey, was duly proposed and elected to membership.

Mr. Proctor plans to spend the summer at Mt. Desert Island. To members of the Society, in the neighborhood during the summer, he very kindly offered to show them around. Members expecting to visit him, however, must let him know in advance.

Mr. Davis, the speaker of the evening was then introduced. The New York Entomological Club, said Mr. Davis, started as Sunday afternoon talks held at the homes of the various members. The Club was founded October 3, 1880, and incorporated in 1893. Mr. Davis read several minutes of the earliest meetings. It was interesting to note that even as early as 1880 there existed serious financial difficulties.

The founders had the unique idea of selecting famous biologists and entomologists as honorary corresponding members. Included in this list were such men as Darwin and Lubbock. The earliest publication was called "Papilio," dedicated to the Lepidoptera, with the idea of eventually adding other topics. A committee was also appointed on nomenclature, the object being to settle doubtful points in connection with synonymy and to arrive at decisions concerning entomological species. Out of the failure of "Papilio," "Entomologica Americana" issued forth.

Mr. Grote, the second oldest member of the Society, said that the club started when New Yorkers rebelled at the idea of going to Brooklyn for meetings. He was president in 1902 and 1903 after having been treasurer for several previous years. Dr. Ditmars, by his permission, was allowed to read his first public paper on the "Snakes of Central Park." Mr. Grote closed his remarks by thanking the Society for being allowed to speak and for being made a life member.

Mr. Bird spoke of the contributions made by the Society and by Mr. Davis to the Society. He instructed Mr. Davis to carry the good wishes of the Society to Mr. Leng.

Mr. Davis regretted very much that the evening was so short that he could not go into more detail. Even though he had to deal with his subject in a superficial way the members found the meeting a most enjoyable one.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF MAY 19, 1936

A regular meeting of the Society was held on May 19, 1936, in the American Museum of Natural History; President Ruckes presiding with nineteen members and eleven visitors present.

The Field Committee reported on plans for a field trip every three weeks during the summer. The schedule of trips was as follows:

May 31	(Sun.)	West Nyack, N. Y.
June 14	(Sun.)	Greenwood Lake, N. J.
July 12	(Sun.)	Lakehurst, N. J.
Aug. 15-16	(Sat.-Sun.)	De Bruce, N. Y.
Sept. 20	(Sun.)	Bear Mt., N. Y.

Dr. Lutz and Dr. Gertsch were ahead of anyone in their spring collecting, having started in on February 5 in Panama. They collected about 17,000 specimens, chiefly Lepidoptera. Dr. Lutz plans to probably continue life history work at Ramsey and also to record the sound of insects. Dr. Gertsch told of the abundance of chiggers or red bugs at Barro Colorado Island. Ticks were also very common.

Doctors Melander and Klots gave a short résumé of some collecting done early this year.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF OCTOBER 6, 1936

A regular meeting of the Society was held on October 6, 1936, in the Roosevelt Memorial; President Ruckes in the chair with twenty-eight members and twenty-four visitors present.

Dr. Ruckes welcomed the Society to its new quarters in the Roosevelt Memorial.

The Field Committee reported that at the Society's first trip of the year twenty members were present. The members were the guests of Mr. Richard. Inclement weather made it impossible for the other scheduled trips to be held.

Dr. Tindale, of the South Australian Museum, was scheduled to speak at the next meeting on "Notes on Insect Collecting in Australia."

Dr. Melander proposed Dr. H. Hagen and Dr. V. Argo, both of the C. C. N. Y. faculty, for membership. Dr. Curran moved that the rules be suspended in order to elect them at once.

Mr. Kisliuk called the attention of the Society to the death of J. W. Folsom.

The speaker of the evening, Dr. Gibson, Dominion Entomologist, was then presented. The Bureau of Entomology in Canada, said Dr. Gibson maintains twenty research laboratories, five or ten temporary field laboratories and ten plant inspection sites. Dr. Gibson explained that insects recognize no



boundary line between Canada and United States. Consequently there is a mutual trading of insect pests beyond the control of either country.

Grasshoppers from U. S. have become so well established 100 miles north of the boundary that effective control measures have to be taken. On the basis of per cent of eggs per area, maps may be made. From these maps the amount of poison necessary to kill the insects the following spring may then be calculated.

Biological control is of vital interest to the Bureau. All of the parasites used are of European origin collected in Hungary and other countries especially for breeding purposes. There are several notable successes in establishing parasites. *Macrocentrus*, a parasite of the peach moth, has become so well established that the peach moth is now seldom found.

The Satin Moth which defoliates trees caused very serious trouble. *Apanoteles* were obtained, bred, and released. This parasite had by 1935 caused infestation of the Satin Moth to completely disappear.

In the Gaspé Peninsula the European sawfly was fast destroying spruce. The parasite *Microplectron* was reared and in 1936, 12,321,426 specimens were liberated. These liberations were usually made in units of 10,000.

Dr. Gibson closed his remarks with a detailed description of the new parasitology laboratory at Bellville. It is the best in the world with all accommodations for complete control of conditions at all times of the year.

At the close of Dr. Gibson's talk there was a general discussion by members.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF OCTOBER 20, 1936

A regular meeting of the Society was held on October 20, 1936, in the Roosevelt Memorial; President Ruckes in the chair with twenty-seven members and fifteen visitors present.

Mr. Henry Bird proposed Professor P. A. Readio, Department of Entomology, Cornell University, Ithaca, N. Y., and Dr. Curran proposed Dr. T. L. Guyton, Sherwin Williams Co., Bound Brook, New Jersey, for membership.

Mr. Engelhardt reminded the members that the next meeting of the Brooklyn Society on November 12 would be in commemoration of the 50th anniversary of its founding.

Dr. Curran made a motion to suspend the by-laws in order to postpone the next meeting because of Election Day.

In view of the fact that there would be no meeting on November 3, Mr. Mutchler proposed suspension of by-laws in order to elect the proposed members to the Society. Acting upon this proposal Professor Readio and Dr. Guyton were elected to membership.

Dr. Ruckes then presented the speaker of the evening, Mr. N. B. Tindale, of the South Australian Museum. From Mr. Tindale the members learned that Australia is troubled by the same insect pests that bother the United States, such as the peach moth. Insects of SW. Australia however are of an archaic nature due to their habit of living in a desert forest.

What is known as Palm Valley is in the midst of sterile desert but in itself it is a gem of fertility. Certain Neuropteroid insects are found only there.

The natives, said Mr. Tindale, are very fond of sweets. In order to obtain this delicacy they take advantage of the way certain ants store honey. They dip up these ants one by one and when they have collected a handful enjoy their rare treat. Children depend largely upon insects for the fat necessary to keep them healthy. They eat from twenty to thirty grubs a day. These grubs may be either toasted or eaten raw.

In times of scarcity of food natives turn up the ground in search of grubs. They also depend upon certain ants that gather grass seed about their mounds. The natives search for these mounds and then use the grain.

Mr. Tindale brought his talk to a close by remarking upon the constancy of association of Australian fauna with that of Patagonia.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF NOVEMBER 17, 1936

A regular meeting of the Society was held on November 17, 1936; President Ruckes in the chair with twenty-four members and seventeen visitors present.

The program committee reported that Dr. Melander would address the Society at the next meeting, his topic being "Behavior of Some Insects and Their Relatives," to be illustrated with motion pictures.

Dr. Ruckes spoke of having visited the Brooklyn Entomological Society on its fiftieth anniversary.

The long-postponed session given over annually to "Notes by Members" was the program of the evening.

Mr. Angell collected at Engelwood Cliffs, N. J. He mentioned *Stratogodes septemtrionus* Csy. and *Nyas cyanescens* as being of special interest.

Mr. Comstock said he made twenty-two field trips. On these trips he collected 3,000 specimens principally in twelve orders. Collecting was very poor and most of it was done by sweeping.

Dr. Lutz spoke of the experiments he made this summer on the sound recording of insects.

Mr. Davis exhibited several interesting cicadas. The types of these species were presented to the American Museum of Natural History. They are: *Tibicen nigraoalbata*, *Platypedia balli* and *Tibicen curvispinosa*. Some cicadas from the southwestern part of the United States, according to Mr. Davis, are similar to those occurring in Europe. He also told of having received *Peripatus (Peripatoides novae-zealandiae)* and *Heterojapyx novae-zealandiae* and these two specimens have been given to the Staten Island Institute of Arts and Sciences.

Dr. Fox during his summer vacation studied the relative abundance of insect population. He found *Conocephalus ornata* which is usually confined to the Mississippi Basin along the Palisades.

Dr. Melander exhibited pictures taken on the first field trip of the season of the New York Entomological Society. These included both motion and still pictures. Studies of the behavior of insects as well as some of their relatives that have occupied Dr. Melander this summer will be the subject of a talk at the next meeting.

Mr. Olsen who was just back from a trip on the *Zaco* to the South Sea Islands related some of his experiences. The object of the trip was to collect material for a Museum group on pearl diving. The short time available to him for entomological purposes netted few specimens.

Mr. Harry B. Weiss spent the summer collaborating with the New York Public Library resulting in an annotated list of insects affecting books.

Carabidæ seemed to be very scarce this year according to both Mr. Proctor and Mr. Nicolay. Mr. Proctor remarked that there seemed to be fewer Carabidæ each year at Bar Harbor. Mr. Nicolay was of the same opinion concerning the scarcity of Carabidæ in Florida and in the vicinity of Washington.

Dr. Smith spent the summer traveling in Europe. He visited various museums in order to study chrysopids. Of all the museums visited he was most enthusiastic of the Live Insect Exhibit at the Berlin Zoological Gardens.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF DECEMBER 1, 1936

A regular meeting of the Society was held on December 1, 1936; President Ruckes in the chair with twenty-seven members and twenty-seven visitors present.

The program committee reported that Dr. Felt would address the Society at the next meeting on "Insect Enemies of Shade and Ornamental Trees," illustrated with lantern slides.

The following were proposed for active membership in the Society: Mr. Louis A. Tomka, 234 E. 36th Street, New York City; Mr. James H. Maier, 284 10th Ave., New York City, and Mr. Alfred Fenton, Texaco Sulphur Co., Second National Bank, Houston, Texas.

The meeting was then given over to the speaker of the evening, Dr. Melander. Discarding the collecting net Dr. Melander spent the summer in taking insects in their natural surroundings. Most of his work was done in New England. The equipment necessary consists of an abundant supply of patience, a quiet day and lots of sunshine. Displayed upon the screen the members then witnessed insects behaving and misbehaving amid their natural surroundings and in color. Everyone enthusiastically praised Dr. Melander's marvelous motion pictures of insects and some of their relatives.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF DECEMBER 15, 1936

A regular meeting of the Society was held on December 15, 1936; Dr. Ruckes in the chair with eighteen members and fifteen visitors present.

The program committee announced that Dr. A. Glenn Richards, Jr., would speak on January 5, 1937, on "Development and Evolution of Wing Patterns of Lepidoptera."

The following were elected active members of the Society: Mr. Louis Tomka, Mr. James H. Maier and Mr. Alfred Fenton.

Dr. Ruckes appointed a nominating committee composed of Mr. Bell, Mr. Sherman and Mr. Mutchler.

An invitation to members to attend the Science Meetings at Atlantic City was read by Dr. Ruckes.

The members discussed the proposed change of name of the American Association of Economic Entomologists to the American Association of Entomologists. A motion was made and seconded that the President or a representative delegate appointed by him would represent the Society in this matter at the Atlantic City meetings.

Dr. Felt, the speaker of the evening, spoke upon "Insect Enemies of Shade Trees." Dr. Felt's talk was illustrated by slides to show the effects of repeated attacks by insects as well as the characteristic damage done by these insect pests.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF JANUARY 5, 1937

An annual meeting of the Society was held on January 5, 1937; President Ruckes in the chair with twenty-five members and seventeen visitors present.

The program committee reported that Mr. Henry Bird would lead the general discussion at the next meeting with remarks on "The Remarkable Insect Fauna of the Fruit of a Native Fig."

Mr. Mutchler read the report of the nominating committee, as follows:

*President*: Dr. C. H. Curran

*Vice-President*: Dr. William Moore

*Secretary*: Lucy W. Clausen

*Treasurer*: Paul T. Richard

*Librarian*: Frank E. Watson

*Curator*: Andrew J. Mutchler

*Executive Committee*: William T. Davis, Frank E. Lutz,

William Proctor, Herbert F. Schwarz, Henry Bird

*Publication Committee*: Harry B. Weiss, H. T. Spieth,

John D. Sherman, Jr., E. L. Bell

*Delegate to the New York Academy of Sciences*: William T. Davis

Nominations were closed and the secretary was empowered to cast one ballot for the officers as nominated.

Dr. Ruckes then turned the meeting over to the new president, Dr. C. H. Curran.

The resignation of Dr. William Wiegman was accepted with regret.



Dr. Wolfgang VonHagen was proposed for active membership.

Dr. Curran appointed the following committees:

*Program:* Dr. A. B. Klots, Dr. A. L. Melander, Mr. M.

Kisliuk

*Auditing:* Dr. A. L. Horsfall, Mr. Frank Johnson, Dr.

Henry Fox

*Field:* Mr. A. S. Nicolay, Mr. H. Moennich, Mr. H.

Dietrich

Dr. A. Glenn Richards, the speaker of the evening, took the floor. The topic discussed was "Development and Evolution of the Wing Pattern of Lepidoptera." The lepidopterous wing is largely a self-differentiating system independent of the rest of the body. This is proven by transplanting anlagen, by culturing anlagen *in vitro* and by delayed development of wings upon which operations have been performed.

There are two fundamental points in the determination of pattern. First, that there are "sensitive periods" during which the pattern may be modified by external agents and before and after which it is unaffected by these same agents. The different parts of the pattern have sensitive periods at different times so that it is possible to modify one pattern-component without in any way affecting the other.

Second, the pattern is irrevocably fixed by a "determination stream" which flows like a stream across the wing, determining the parts thereof. There are two types of determination streams known: one from the base outward (based on the analysis of intersexes and gynandromorphs), the other from the ventral surface over the central symmetry-field.

There is fundamental similarity between the results of comparative-morphology, developmental physiology and genetical analyses of mixed populations. This work proves that "aberrations" have no status in phylogeny, but are merely *normal* individuals which by chance have developed under not normal conditions.

Seasonal forms are viewed as generally due to diapause versus non-diapause development.

A complete review of this subject is to appear in the June issue of the JOURNAL.

A general discussion followed the talk of the evening.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF JANUARY 19, 1937

A regular meeting of the Society was held on January 19, 1937; President Curran in the chair with twenty-five members and fifteen visitors present.

The Secretary being absent Dr. Ruckes was asked to be secretary *pro tempore*.

The program committee reported that at the next meeting Dr. C. C. Hamilton would address the Society on "The Use of Autogyro and Airplane in

Insect Control." Dr. Hamilton is from the New Jersey State Experiment Station.

Dr. Wolfgang VonHagen was elected to active membership.

The President called attention to the untimely deaths of Professors Crosby and Tillyard. On motion duly seconded and passed Dr. Klots and Dr. Leonard were instructed to write a letter of condolence on behalf of the Society.

Mr. Comstock recalled a series of lectures of which he showed the outline that were given in the American Museum of Natural History in 1894. He also recalled the interesting memorandum of an auction of Lepidoptera conducted by Dr. Ottolengui in 1896. Mr. Davis said that the success of such auctions was due to the leadership of Mrs. Annie Trumbull Slosson and that there were few auctions because the financial condition of the Society improved rapidly and there was no need of raising money by this method.

Mr. Comstock further remarked upon the possible use of paradichlorobenzene as a therapeutic means of controlling ringworm infections.

The program of the evening was opened by Mr. Henry Bird who gave a most interesting talk on the Insect Fauna of the Native American Fig." The remarkably numerous insect fauna of a native fig, *Ficus populina* Willd., of southern Florida was discussed by Mr. Bird and particular attention was drawn to the presence of a *Blastophaga* species seemingly different from *B. grossorum* which was the foreign species introduced into southern California for the caprification of the Smyrna fig. The growing of this variety of the fig in favorable regions of the southwest was equally dependent on this minute wasp to carry pollen from another form bearing staminate flowers, the same as happen in Asia Minor. Its introduction and the working out of its complicated biology was pointed out as a classic of entomology along with that of the *Pronuba* moth and the cross-pollination by the latter of the Yucca plant.

If in the discovery of this Floridian *Blastophaga* it proves that we are dealing with a native species, it might have been of equal assistance to the Californian fig growers, as the imported one. These female wasps are concerned with placing their eggs in the flower of some other fig than that from which they emerged and any in proper condition seem to do so, as long as they are near at hand. Only males without wings and curious creatures, were encountered. These formed but a small fraction of the hundreds of examples emerging from *F. populina* fruit wherein occurred seven other species of Chalcidoidea, and a new gall midge of the genus *Ficiomyia*.

Mr. George Rau gave an excellent summary of the scale insects found in the greenhouses at Bronx Park. His remarks were illustrated by a large collection of living scales which he showed. In 1921 Dr. Morrison found thirty-nine species of scale insects in the greenhouses of the New York Botanical Gardens. During the course of Mr. Rau's collecting he has found twenty-two new records in the same greenhouses, eight of which have been previously recorded by others from different greenhouses in the state. The following are recorded for the first time from the U. S.:

*Asterolecanium aureum* Bdv.

*Chrysomphalus umbonatus* Newst.

*Kuwanaspis hikosani* Kw.

*Lecanium decemplex* Newst.

In a preliminary survey of the same greenhouses the following parasites of scale insects were found:

*Aphytis diaspidea* How. on *Diaspis zamiae* Morg.

*Aphytis chrysomphali* Mercet on *Chrysomphalus umbonatus* Newst.

*Aspidiotiphagous citrinus* Craw. on *Kuwanaspis hikosani* Kuw.

*Coccophagus immaculatus* How. on *Ericoccus azaleae* Comst.

*Coccophagus lycimnia* Walker (*C. lecanii* Fitch) on *Coccus hesperidum* L.

*Encyrtus infelix* Embleton on *Saissetia hemisphaerica* Targ.

*Leptomastidea abnormis* Gir. on *Pseudococcus citri* Risso

In addition the thrips *Aleurodothrips fasciapennis* Franklin is predacious upon *Saissetia hemisphaerica* Targ. and *Watsoniella elongata* Watson is commonly found attacking *Odonaspis secreta* Ckll.

Undoubtedly the most serious insect pests of greenhouse plants are the mealy bugs of which six species require control measures.

The Mexican mealybug *Phenacoccus gossypii* is considered by many entomologists the most serious insect found in greenhouses. This insect has gained entrance into a number of greenhouses within the last ten years and may do great damage to Chrysanthemums and other plants.

*Rhizoecus falcifer* Kunk. attacks the roots of palms. The cottony masses of this insect are mistaken for a fungus growth.

The greenhouse whitefly *Trialeurodes vaporariorum* Westw. is heavily parasitized by *Encarsia formosa* Gahan and the entomogenous *Aegerita webberi* Fawcett.

LUCY W. CLAUSEN, *Secretary.*





# The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943.

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

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## Officers for the Year 1937

*President*, DR. C. H. CURRAN.....American Museum of Natural History

*Vice-President*, WM. MOORE.....American Cyanamid Co., New York, N. Y.

*Secretary*, LUCY W. CLAUSEN.....American Museum of Natural History

*Treasurer*, PAUL T. RICHARD.....American Museum of Natural History

*Librarian*, F. E. WATSON.....American Museum of Natural History

*Curator*, A. J. MUTCHLER.....American Museum of Natural History

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H. F. SCHWARZ.....HENRY BIRD

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## AUDITING COMMITTEE

DR. J. L. HORSFALL.....FRANK JOHNSON.....DR. HENRY FOX

## FIELD COMMITTEE

A. S. NICOLAY.....HENRY DIETRICH.....HERMAN MOENNICH

## DELEGATE TO THE N. Y. ACADEMY OF SCIENCES

WILLIAM T. DAVIS

# JOURNAL

of the

## NEW YORK ENTOMOLOGICAL SOCIETY

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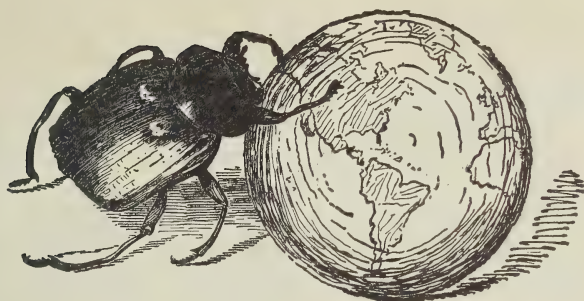
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# JOURNAL

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### SEVEN NEW SPECIES OF ASIATIC TIPHIA

BY L. B. PARKER

ASSISTANT ENTOMOLOGIST, DIVISION OF JAPANESE AND ASIATIC BEETLE  
INVESTIGATIONS, BUREAU OF ENTOMOLOGY AND PLANT QUARAN-  
TINE, U. S. DEPARTMENT OF AGRICULTURE<sup>1</sup>

#### INTRODUCTION

In the course of the scouting and experimental work carried on at the Yokohama Laboratory of the Division of Japanese and Asiatic Beetle Investigations during 1931 and 1932 a collection of specimens of *Tiphia* was accumulated which, subsequent studies revealed, involve several new species. The guide used during the study of this collection was the publication "Contribution to the Taxonomy of Asiatic Wasps of the Genus *Tiphia* (Scoliidae) by Allen and Jaynes."<sup>2</sup> Although it was obvious that some of the specimens were closely related to species represented in Allen and Jaynes' key, the lack of sufficient material for comparative purposes made it necessary for the author to postpone more conclusive studies until his return to the United States. With the aid of the collection of Asiatic *Tiphia* at the

<sup>1</sup> The author sincerely appreciates the cooperation of H. W. Allen, whose helpful advice and criticism were so willingly given. Thanks are also due to K. Sato for his assistance in originally segregating the new species in the Yokohama Laboratory collection.

<sup>2</sup> Contribution to the Taxonomy of Asiatic Wasps of the Genus *Tiphia* (Scoliidae). H. W. Allen and H. A. Jaynes. No. 2814.—From Proceedings of the United States National Museum, Vol. 76, Art. 17, pp. 1-105, illus. 1930.

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laboratory at Moorestown, N. J., this work was finally completed and the seven new species presented in this paper were described.

No rearing work was conducted with the species *corpulenta* and *mediocris* but the males used in the descriptive work were collected under circumstances which leave little doubt as to the authenticity of their relationship to the female types. The description appearing herein are, for the most part, given in the descriptive style and phraseology employed by Allen and Jaynes, changes being made only where new diagnostic characters are involved.

#### GROUPING OF THE NEW SPECIES

Allen and Jaynes, in their publication previously referred to, have divided the species represented in their key into eight taxonomically related groups, each group bearing the name of the species most typically representative of it. This same system has been used in the present paper and each of the seven species herein described has been assigned to its respective group as determined by Allen and Jaynes. These authors place *Tiphia vernalis* Roh. in a position by itself although indicating a relationship to the *agilis* group. Since the species herein described as *Tiphia burrelli* runs out to *vernalis* in the aforementioned key, it is grouped with that species in this paper, although the characters of the female more closely resemble those of *popillavora* than those of *agilis*.

The case of *Tiphia homoncularis*, n. sp., however, appears to be a departure from the grouping of species as laid down by Allen and Jaynes. In this species the female keys out to *agilis* of the *agilis* group while the male keys out to *malayana* of the *malayana* group. Apparently *homoncularis* is a species which may be considered as a connecting link between these two groups, whose representatives are, in fact, not radically different from one another, particularly as to male characters.

In the following tabulation are listed the species described in this paper together with the couplet numbers to which they run in the above-mentioned key, and the groups within which they fall.

## Couplet Nos.

<i>Name</i>	<i>Female</i>	<i>Male</i>	<i>Group</i>
<i>Tiphia homoncularis</i> .....	24	17	agilis-malayana
<i>Tiphia juliana</i> .....	37	24	agilis
<i>Tiphia isolata</i> .....	7	24	rufomandibulata-agilis
<i>Tiphia corpulenta</i> .....	32	19	popilliavora
<i>Tiphia mediocris</i> .....	32	19	popilliavora
<i>Tiphia burrelli</i> .....	38	15	vernalis
<i>Tiphia castaneaeavora</i> .....	37	24	agilis

Each of the above-listed species runs out to the indicated couplet in the key by Allen and Jaynes, and for purposes of further identification the following key is offered.

## KEY TO FEMALES

- A.—With hind basitarsus grooved.
  - B.—Side of pronotum with a groove across center.
    - C.—Tegula red, transparent and thin ..... *homoncularis*
    - CC.—Tegula black and opaque.
      - D.—Pygidium with impunctate apex wrinkled.....*corpulenta*
      - DD.—Pygidium with impunctate apex smooth.
        - E.—Mandibles at least with a shallow median groove.
          - .....*mediocris*
          - EE.—Mandibles without median groove.....*burrelli*
    - BB.—Side of pronotum without a groove across center.
      - F.—Second intercubital vein strongly sinuous..... *castaneaeavora*
      - FF.—Second intercubital vein straight or nearly so..... *juliana*
  - AA.—With hind basitarsus not grooved ..... *isolata*

## KEY TO MALES

- A.—Antennocular distance less than width of antennal fossa.
  - B.—Tegula with Tegula with groove on lateral or posterior margin ..... *burrelli*
  - BB.—Tegula without such a groove ..... *homoncularis*
- AA.—Antennocular distance at least as great as width of antennal fossa.
  - B.—Clypeal extension having an impunctate margin.
    - C.—Lower half of front lightly shagreened; primary punctures of clypeo-antennal region confined to a patch but little broader than base of clypeal extension..... *corpulenta*
    - CC.—Lower half of front not shagreened; primary punctures of

- clypeo-antennal region extending across greater portion of this region ..... *mediocris*
- BB.—Clypeal extension without impunctate margin.
- C.—First sternite with longitudinal extension of median keel faintly discernible to posterior sulcus; median extension of clypeus truncate; sides of propodeal areola concave..... *isolata*
- CC.—First sternite without such longitudinal extension of median keel; median extension of clypeus roundly emarginate; sides of propodeal areola nearly straight though convergent posteriorly.
- D.—Punctures on anterior portion of first sternite much larger and coarser than those in preapical band of first tergite ..... *juliana*
- DD.—Punctures in anterior portion of first sternite but little larger than those in preapical band of first tergite. *castaneaevora*

#### ***Tiphia homoncularis* new species**

FEMALE.—Vertex with a few series of primary punctures of second-degree density extending through and behind ocellar triangle, primaries denser medially than on either side. Front very faintly shagreened, visible in strong light; groove, if present, frequently interrupted; primary punctures sparse, denser on anterior third, where they are evenly distributed between the eyes, chiefly of second-degree density, except broadly on the median upper front, where density is of third degree. Impunctate apex of clypeal extension poorly defined by an irregular row of coarse punctures, its longitudinal extension approximately one-half the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Pronotum with primary punctures on posterior margin of punctate area deeper than other primary punctures in this area; secondary punctures sparse and widely scattered; sides of pronotum with well defined groove across center. Scutum with its notauli and its antero-medial groove continuous or nearly so. Metanotum beset with primary and secondary punctures on its periphery, with its largest discal punctures smaller than those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with a shallow groove extending about one-half the length of the joint, and a group of three lanceolate spines on the outside, one of which is apical. Tegula thin, red, polished and transparent. Wings slightly smoky. Propodeal areola almost rectangular, two and one-half to three times as long as wide; carinae narrow and uniform, bordering grooves if present shallow and interrupted; median carina ending just before posterior transverse carina. Lower portion of sides of propodeum shagreened, with patch of microscopic appressed hairs in posterior angle. Posterior aspect of propodeum with median carina weak but complete. First abdominal tergite with single band of well defined punctures across dorsum, becoming wider and abruptly depressed laterally. First sternite with lateral grooves on



posterior half, and a few scattered punctures anteriorly. Tergites polished, impunctate margins medially about 3 to 4 times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half, with polished impunctate emargination; apex scarcely wrinkled and not shagreened. Length 6 to 9 mm.

MALE.—Vertex with primary punctures in and immediately behind ocellar triangle more numerous than on either side. Front at least faintly shagreened; preocellar area on upper half with primary punctures in uniform second-degree and third-degree density and with interspaces at least as broad as an ocellus; secondary punctures generally lacking though primaries gradually diminish in size toward bases of antennæ. Antennocular distance less than width of antennal fossa. Clypeal extension with its apical width at least as great as distance from apex of clypeus to edge of antennal fossa; disk flat, apex distinctly roughly emarginate, with narrow, irregularly impunctate area antero-medially. Flagellum infuscated beneath. Pronotum faintly shagreened; primary punctures largely of third-degree density; a few scattered secondary punctures antero-medially. Side of pronotum striate, with groove extending across center in broadly rounding curve for at least one-half the width of the sclerite; no punctures. Mesepisternum shagreened; primary punctures diminishing in size and density away from prepectus, everywhere of third-degree density; secondary punctures conspicuously less numerous than primaries over a vaguely defined area in center anterior to spiracle. Scutellum without impunctate apex as wide as lowest primary punctures. Metanotum variable. Tibiæ and femora partly reddish. Tegula polished, red to red-black, and transparent. Wings subhyaline, with radial cell exceeding second cubital cell in apical extension. Propodeum with its transverse carina extending far forward medially; areola two to two and one-half times as long as wide, its sides slightly divergent anteriorly, the lateral carinæ bordered on the outside by shallow indistinct crenulate grooves, the median carina extending from anterior limit of areola posteriorly three-fourths to four-fifths the distance to transverse carina; lower portion of sides of propodeum finely striate, devoid of hairs or punctures; posterior aspect with lower three-fourths covered with fine hairs and minutely punctate, upper fourth polished, and generally with a few scattered, shallow, coarser punctures medially; median carina weak, rarely present on more than lower three-fourths. First tergite with narrow preapical band of well differentiated punctures in slight depression. First sternite polished, lateral grooves faint and interrupted on more than posterior half; impunctate except for occasional scattered punctures on anterior half, constricted portion with an elongate median keel. Tergites 3 to 5 with punctures clearly outlined, apical ones larger than the more densely group anterior ones; impunctate margins at most about three times width of largest adjacent primary punctures. Length 4.5 to 5.5 mm.

DISTRIBUTION.—Nagano-ken, Gifu-ken, Kanagawa-ken, Honshyu, Japan; Suigen, Chosen (Korea).

TYPE AND ALLOTYPE.—Cat. No. 51086, U. S. National Museum; Type, female, Ueda, Nagano-ken, Japan, September 19, 1931 (H. Sugiura); allotype, male, Kagamigahara, Gifu-ken, Japan, October 1, 1931 (H. Sugiura).

PARATYPES.—Deposited in the collection of the U. S. National Museum: Two females and one male, Japanese Beetle Parasite Experiment, August 12, 1933. Deposited in the Academy of Natural Sciences of Philadelphia: Three females and two males, Japanese Beetle Parasite Experiment, August 12, 1933. Retained in the collection of the Japanese Beetle Laboratory: Three females, Suigen, Chosen, August, 1923 (C. P. Clausen), and two males, Japanese Beetle Parasite Experiment, August 12, 1933.

Specimens labeled Japanese Beetle Parasite Experiment emerged at the Japanese Beetle Laboratory at Moorestown, N. J., from cocoons reared and shipped by the field station in Japan. The diagnostic characters of the females of *T. homoncularis* and *T. agilis* are very similar. The most noticeable difference lies in the extent of the impression anterior to the transverse band of punctures on the first tergite. In *T. agilis* (also *T. asericæ*) the impression can be discerned extending diagonally forward from the median portion of the transverse band of punctures and at a slight angle to it, while in *T. homoncularis* the impression is discernible only in limited areas anterior to the lateral extremities of the transverse band of punctures.

In *T. homoncularis* the front, while polished, may be seen to be very faintly shagreened if viewed in a strong light. The front in *T. agilis* shows no shagreening.

The outstanding character differences between the male of *T. homoncularis* and that of *T. malayana* are in the tegulæ, which in the former are very thin, transparent, red, and show no shagreening while those of the latter are reddish to opaque black and are shagreened. They also exhibit a shallow but distinct groove along the posterior margin which is lacking in the case of *T. homoncularis*.

The region immediately anterior to the transverse band of punctures on the first tergite is much more abruptly impressed in the males of *T. malayana* than in those of *T. homoncularis*. In the former a distinct ridge is noticeable paralleling the trans-

verse band of punctures for almost its entire length. The male of *T. homoncularis* lacks this ridge except to a barely noticeable degree at the very extremities of the transverse band of punctures.

*T. homoncularis* has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 16.

***Tiphia Juliana* new species**

FEMALE.—Vertex with a few series of primary punctures of second-degree density extending through and behind ocellar triangle, primaries denser medially than on either side. Front polished; groove present though frequently interrupted; primary punctures sparse, slightly more numerous on anterior third where they intermingle with scattered secondaries in even distribution from eye to eye, primaries chiefly of second-degree density except broadly on median upper front where density is of third-degree. Clypeal extension with its impunctate apex defined by an irregular row of coarse punctures, its longitudinal extension about one-third of the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Punctures on dorsum of pronotum slightly more dense medially where primaries and secondaries mingle than on either side, secondaries elsewhere on dorsum of pronotum sparse but well differentiated. Sides of pronotum striate, without a groove across the center, but with striations in this region sometimes increased to short, shallow, irregular grooves. Scutum with its notauli and its antero-medial groove continuous or nearly so. Metanotum densely beset with primary and secondary punctures on its periphery, with its largest discal punctures nearly as large as those of the scutellum. Legs with major calcarium of hind tibiae widest at the band near middle; hind basitarsus with groove, shallow and extending about one-half the length of the joint, a group of three lanceolate spines on outside, one of which is apical. Tegula thin, red, polished, transparent. Wings slightly smoky. Propodeal areola with hastate outline, two and one-half to three times as long as its anterior width, median carina incomplete. Lower portion of sides of propodeum shagreened, no patch of microscopic, appressed hairs. Posterior aspect of propodeum coriaceous, median carina weak and flattened, rarely complete. First abdominal tergite with well developed pre-apical band of punctures the lateral portions of which have the punctures more or less coalesced in sharp depression, median punctures of band single and well differentiated. First sternite with lateral grooves on posterior half, and a few scattered punctures anteriorly. Tergites with polished impunctate margins, medially about 3 to 4 times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half; apex smooth but not polished. Length 8 to 8.5 mm.

MALES.—Vertex with primary punctures everywhere of third-degree density. Front with rather small primary punctures, lacking usual patch of



punctures on lower front; preocellar patch on upper half very wide, with primary punctures of irregular second-degree and third-degree density, and with interspaces broader than an ocellus; secondary punctures very dense below, not well differentiated from primaries on area where both primaries and secondaries occur, ascending half way to lowest ocellus medially and about one-third the way along the eyes. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-fifths of the distance from apex of clypeus to edge of antennal fossa; disk flat and not protruding; apex shallowly emarginate, lacking an impunctate margin, but with a thick edge. Pronotum with primary punctures small, fairly well outlined, largely of third-degree density; a few secondary punctures close to carina. Side of pronotum finely striate without a definite medial groove. Mesepisternum with small, sparse, well outlined primary punctures denser on the upper half, secondaries everywhere at least as numerous as primaries except on small callosity above coxa, densest along the finely crenulate groove bordering prepectus and next to impunctate posterior margin. Scutellum, except medially, with impunctate apex not as wide as largest apical primary punctures. Metanotum with dense secondary punctures apically, elsewhere with sparse primaries nearly equaling the largest of the scutellum in size. Tibiæ and tarsi of first two pairs of legs mostly reddish. Tegula polished, translucent, red. Wings with radial cell at most equaling second cubital cell. Propodeum with sides of areola converging posteriorly to give keystone shape to areola, which is about twice as long as its anterior width, lateral carinæ without bordering grooves, the median carina sinuous, the enclosed area somewhat rugose. Side with lower region not punctate or hairy but finely shagreened; posterior aspect densely hairy and coarsely coriaceous in lateral angles, with median carina on not more than lower half. First tergite with preapical band broadening laterally, where punctures become more clearly differentiated from coalesced area, uniformly, deeply impressed to lateral aspects of tergite, where the ridge on the anterior margin of the band disappears. First sternite with lateral grooves on posterior third, disk polished, impunctate between lateral grooves, coarse scattered punctures increasing in density from anterior terminals of lateral grooves toward escutcheon, until moderate-sized median keel is embraced by deep coalesced punctures. Tergites 3 to 5 moderately shagreened, with punctures extending to apex. Fifth sternite with its lateral denticle appearing more like a crescent than a tooth. Length 6 to 7 mm.

DISTRIBUTION.—Akita-ken, Iwate-ken, Yamagata-ken, Miyagi-ken, Nagano-ken, Kanagawa-ken, Honshyu, Japan; Sapporo, Hokkaido, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51087, U. S. National Museum. Type, female, Hokkaido, August 29, 1931 (K. Sato); allotype, male, Kotoni, Hokkaido, August 24, 1931 (K. Sato).

PARATYPES.—Deposited in National Museum: One female, Hokkaido, August 29, 1931 (K. Sato.) Retained in the collection



of the Japanese Beetle Laboratory; One female and one male, Makomonai, Hokkaido, August 28, 1931 (K. Sato).

In the key by Allen and Jaynes this species runs out to second alternate of couplet 37 in the key to females and to the second alternate of couplet 24 in the key to males (*T. asericæ*). The differences in diagnostic characters between *T. juliana* and *T. asericæ* are much more apparent in the female than in the male. The impunctate apex of the pygidium of the female *T. juliana* is smooth but not polished and lacks the impunctate emargination which characterizes the polished impunctate apex in the pygidium of *T. asericæ*. The second intercubital vein of female *T. juliana* is practically straight while that of *T. asericæ* is sinuous.

The males of *T. juliana* show a more uniform first-degree primary punctation on the dorsum of the pronotum than that exhibited by the males of *T. asericæ*.

*T. juliana* has been known in the past to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 24.

#### ***Tiphia isolata* new species**

FEMALE.—Vertex with a few punctures of second-degree density just behind ocellar triangle and narrowly along upper eye orbits, punctures elsewhere of sparse third-degree density. Front polished, median carina usually pronounced, shallow median groove extending upward from median carina varying distances toward ocellar triangle; primary punctures denser in area immediately above bases of antennæ than on either side, largely of second-degree density on lowest third and upward along the eyes, of distinctly third-degree density in preocellar area, where there are impunctate interspaces at least as broad as an ocellus. Antennæ uniformly dark brown with silvery pubescence. Clypeal extension with longitudinal extension of impunctate margin about one-third of the distance from apex of clypeus to edge of antennal fossa. Pronotum with transverse carina complete, primary punctures uniform in size and distribution, transverse discal band of punctures rarely present, density chiefly of second degree and third degree; secondary punctures sparse across dorsum of pronotum, frequently of second-degree to third-degree density on lateral disks and narrowly along transverse carina; impunctate area with a median prolongation of varying width, which makes the punctate portion narrower medially than the impunctate portion. Sides of pronotum without any groove across center, finely and uniformly striate over entire flat surface of the sclerite. Metanotum finely punctate on its periphery, the largest punctures much smaller than any on scutellum, median area with scattered microscopic punctures. Legs with major calcarium of hind tibiæ not abruptly bent or wider near middle than at base; hind basi-

tarsus without groove, with three inconspicuous lanceolate spines in a row on outside, one of which is apical. Tegula dark reddish and semitransparent. Wings smoky. Propodeal areola vase-shaped in outline, nearly twice as long as its anterior width; median carina extending at least to lowest fifth, on each side of median carina a shorter and less clearly defined sinuous carina; enclosed area shagreened anteriorly, reticulated behind. Lower portion of side of propodeum weakly rugose, without apparent hairs. Posterior aspect of propodeum granulated, medial carina lacking. First tergite with a preapical band of punctures rather irregular as to size and arrangement, but well separated except laterally, where the band is slightly expanded and the punctures coalesced. First sternite polished, almost devoid of hair and with lateral grooves on posterior half or less. Tergites 2 and 4 with impunctate apices widest at middle, where they are at least four times as wide as the adjacent primary punctures. Pygidium reticulato-punctate on basal half; apical section wrinkled longitudinally on lateral portions, impunctate area shagreened. Length 4 to 6 mm.

MALE.—Vertex with primary punctures everywhere of third degree density, though slightly more frequent in area posterior to ocellar triangle than on either side. Front shagreened; primary punctures in preocellar area of third-degree density and with numerous interspaces as broad as an ocellus; density of primaries gradually increasing toward orbits, attaining first-degree density along their edges; secondary punctures not well differentiated, a dense patch ascending medially half way to ocellus, but less dense and not nearly so high beside the eyes. Antennocular distance equal to width of antennal fossa. Distance from apex of clypeus to edge of antennal fossa slightly greater than width of clypeal extension at its apex; punctures of clypeal extension continues to its margin, which is slightly emarginate and not flattened. Flagellum wholly black. Pronotum with small, poorly outlined primary punctures uniformly distributed and of third-degree density everywhere on dorsum of pronotum except for a narrow median impunctate emargination which divides the punctate area; secondaries slightly more numerous than primaries and interspersed with them. Sides of pronotum broadly striate, without any definite groove across its center but with striations in this region increased to short, irregular grooves. Mesepisternum beset with primary and secondary punctures over entire convex portion, the primaries at least as abundant as the secondaries everywhere except in the angle of the epinemia below the tegula. Metanotum moderately punctate, the punctures everywhere much finer than the coarsest punctures of the scutellum. Tibiæ of first two pairs of legs red. Tegula reddish and semitransparent except at base. Wings hyaline, with radial cell at most slightly exceeding second cubital cell. Propodeal areola vase shaped, about one and two-thirds times as long as its anterior width; lower portion of sides shagreened; posterior aspect granulated, with a single row of closely set, coarse punctures along the polished, impunctate transverse carina, median carina incomplete. First tergite with a preapical band of irregular punctures which is about one puncture wide at middle and broadening laterally, all punctures clearly defined. First sternite

with lateral grooves on posterior half or less, disk polished, median keel faintly discernible entire length of sternite to posterior sulcus, although the raised portion of the keel extends less than half this distance. Tergites 3 to 5 with rather fine, poorly outlined punctures; impunctate margin medially scarcely three times the width of largest adjacent punctures. Length 4.5 to 5.5 mm.

DISTRIBUTION.—Kanagawa-ken, Hyogo-ken, Nagano-ken, Honshyu, Japan; Oita-ken, Kumamoto-ken, Miyazaki-ken, Kago-shima-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51088, U. S. National Museum. Type, female, Yokohama, Japan, October 12, 1932; allotype, male, Yokohama, Japan, September 10, 1932 (L. B. Parker).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker). Deposited in the collection of the Academy of Natural Sciences of Philadelphia: Two females, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker). Retained in the collection of the Japanese Beetle Laboratory: Two females, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker).

The female of *T. isolata*, n. sp., keys out, in Allen and Jaynes' key, to the second alternate of couplet 7, which is *T. lyrata*, but *T. isolata* differs substantially from that species. The male of *T. lyrata* is not known and therefore the male of *T. isolata* can not be compared with it. When Allen and Jaynes' key is used for the male of *T. isolata* the nearest couplet for which it qualifies is No. 24, which is *T. agilis*. This at first seems awkward, since *T. agilis* and *T. lyrata* are members of two different groups as set up by Allen and Jaynes, but since *T. lyrata* is represented in the key only by the female, the male of its relative *T. isolata* would naturally fall into the couplet designating the species which the male next most nearly resembled, regardless of the group to which it belongs. The female of *T. isolata* may be distinguished from that of *T. lyrata* by the shagreening on the impunctate apex of the pygidium. The pygidia in the females of both species are wrinkled longitudinally, but that of *T. lyrata* shows no distinct shagreening on the impunctate portion while in *T. isolata* shagreening is present and distinctly so in the im-



punctate emargination. The female of *T. lyrata* also has, on the fourth tergite, a vestigial row of minute punctures extending dorsally over the center of an otherwise impunctate apex, which character is absent in the females of *T. isolata*.

The males of *T. isolata* and *T. agilis* differ in that there is an abrupt impression immediately anterior to the transverse band of punctures on the first tergite of *T. agilis*, which impression is very slight in *T. isolata* and lacking entirely in abruptness.

*T. isolata* has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 25.

#### ***Tiphia corpulenta* new species**

FEMALE.—Vertex usually without minute punctures dorsally, rarely with a few along median line; with primary punctures denser just back of ocelli than on either side, mostly of second-degree density, with irregular impunctate areas laterad of outside ocelli. Front with punctures not denser on anterior half than elsewhere, everywhere of second-degree density, with occasional impunctate areas as broad as lowest ocellus. Clypeus with its lateral margin usually distinctly convex; impunctate margin defined by an irregular row of punctures, its length at least two-fifths of distance from apex of clypeus to edge of antennal fossa. Mandibles with a shallow but uninterrupted groove. Pronotum with its transverse carina complete; punctures of variable size; primary punctures confined chiefly to the irregular transverse discal band and to a medial patch anterior to it; the transverse discal band containing several punctures in its dorsal aspect which are much larger and deeper than any other punctures on the pronotum; punctures anterior to transverse discal band and on each side of median patch largely true secondaries and distinctly of third-degree density. Side of pronotum with a definite groove across the center merging with a series of anastomosing grooves anteriorly; conspicuously striate in ventral corner, with a few punctures along dorsal border. Metanotum with a shallow median impression; size of punctures variable, with maximum density along posterior edge, the larger punctures not nearly equal in size to the largest punctures of the scutellum. Legs with major calcarium of hind tibia distinctly widest at bend near middle; hind basitarsus with a deep groove and 3 or 4 lanceolate spines on the outside, one of which is apical. Tegula with inner hind corner not produced in a broad angle, only sparsely hairy, with no hairs extending far above tegula when viewed from opposite side. Wings smoky; first cubital mark vaguely defined. Propodeal areola with sides nearly parallel, two to two and one-half times as long as wide, its carinae narrow and usually bordered by well developed grooves; median carina becoming less distinct posteriorly and ending at least one-fifth the distance before posterior limit of areola. Lower portion of sides of propodeum shagreened, with a patch of



very fine hairs posteriorly. Propodeal slope without well developed punctures; median carina flattened and usually confined to lowest two-thirds. First abdominal tergite with its transverse preapical band of punctures varying from one puncture wide at the center to several punctures wide at its lateral extremities, not in a depression and with most of the punctures separated. First sternite with uninterrupted lateral grooves extending over not more than posterior half of sternite, and with scattered shallow punctures confined to lateral portions of posterior half. Tergites with punctures slightly farther from apex medially than laterally; impunctate border of tergites 3 and 4 two to four times as wide as hindmost primary punctures. Pygidium densely reticulato-punctate on basal three-fifths; impunctate apex with numerous wrinkles, broadly shagreened on impunctate portion. Length 14 to 15 mm.

MALE.—Vertex with postocellar area densely beset with primary and secondary punctures, each present in second-degree to third-degree density. Front faintly shagreened, with primary punctures on lower portion sparser and more limited in distribution medially than along eyes; preocellar area with numerous large interspaces, some as broad as an ocellus; secondary punctures forming a dense patch on lower third, extending upward slightly more medially than near the eye. Antennocular distance and width of antennal fossa approximately equal. Clypeal extension with its apical width slightly over one-half as great as distance from apex of clypeus to edge of antennal fossa; apex shallowly emarginate; margin polished, impunctate and slightly up-curved. Pronotum with primary punctures somewhat denser medially than on humeri, mostly of third-degree density; secondaries widely and sparsely distributed. Side of pronotum finely striate, with a strong, uninterrupted groove across its center. Mesepisternum with primary punctures deep and clearly outlined, everywhere of third-degree density; secondary punctures much more numerous than primaries, densely studding the interspaces. Scutellum with impunctate apex at least as wide as diameter of apical primary punctures. Metanotum with a shallow median impression, densely punctate, with primary punctures nearly as large as those of scutellum. Tegula black, with a definite though fine impression along outer margin. Wings with radial cell and second cubital cell equal in apical extension. Propodeum with its areola from one and one-fourth to one and one-half times as long as its anterior width, its sides slightly convergent posteriorly, and convex rather than concave, the median carina bordered by wide, shallow, crenulate grooves and ending in irregular sculpturing of varied proportions well before apex of areola, enclosed area irregularly and transversely rugose and granulate; lower portions of sides densely shagreened; posterior aspect granulate, the minute punctures poorly outlined, the median carina developed on the lower half or more. First tergite with preapical band of punctures widening laterad of the center, its anterior margin abruptly impressed, only the hindmost punctures in the band well differentiated. First sternite with apical fossa obsolete; disk polished, impunctate on area enclosed between two lateral grooves which extend, slightly incurving, over posterior half of sternite; median keel weak, bordered by shallow crenulate grooves and flanked by

irregular coarse punctures extending anteriorly from terminals of lateral grooves. Tergites 3 to 5 usually shagreened; punctures deep, with clearly outlined margins; impunctate margins absent, or at most only as wide as the diameter of the largest adjacent primary punctures; denticle on fifth sternite appressed, its elevated margin moderately long, crescent shaped, and nearly parallel to apex of sternite, frequently with smaller denticles similarly located on the fourth and third sternites. Length 11 to 12 mm.

DISTRIBUTION.—Oita-ken, Kumamoto-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51089, U. S. National Museum. Type, female, Kuju, Oita-ken, Kyushu, Japan, September 10, 1931; allotype, male, Kuju-mura, Oita-ken, Japan, September 10, 1931 (K. Sato).

PARATYPES.—Deposited in the Academy of Natural Sciences of Philadelphia: One female, Kuju-mura, Oita-ken, Kyushu, Japan, September 9, 1931, and one male, Kuju-mura, Oita-ken, Kyushu, Japan, September 10, 1931 (K. Sato). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: One female, Kuju-mura, Oita-ken, Kyushu, Japan, September 10, 1931, and one male, Kuju, Oita-ken, Kyushu, Japan, September 10, 1931 (K. Sato).

In the publication by Allen and Jaynes this species runs out to the first alternate of couplet 32 in the key to females and to the second alternate of couplet 19 in the key to males (*T. phyllophagæ*). The female of *Tiphia corpulenta* differs from the female of *T. phyllophagæ* in that, generally speaking, it is larger than *T. phyllophagæ* and has definite shagreening on the unwrinkled portion of the impunctate apex of the pygidium; whereas the shagreening in the case of *T. phyllophagæ* is confined to the wrinkled portion. The lateral margin of the clypeus in the female of *T. corpulenta* is usually distinctly convex while in *T. phyllophagæ* it is straight.

MALE.—The males of these two species are very similar in appearance, with the exceptions that in *T. corpulenta* the impunctate apex of the scutellum is at least as wide as the diameter of the apical primary punctures, and the sides of the propodeal areola are convex, while in males of *T. phyllophagæ* the impunctate apex of the scutellum is not as wide as the diameter of the apical primary punctures, and the sides of the propodeal areola are slightly concave.

*T. corpulenta* has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 26.

***Tiphia mediocris* new species**

FEMALE.—Vertex usually without minute punctures dorsally, rarely with a few along the medial line; with primary punctures denser just back of ocelli than on either side, mostly of second-degree density, with irregular impunctate area laterad of outside ocelli. Front with primary punctures not denser on anterior half than elsewhere; everywhere of second-degree density, without pronounced impunctate areas. Clypeus with its lateral margin straight; impunctate margin of extension defined by an irregular row of punctures, its length two-fifths the distance from apex of clypeus to edge of antennal fossa. Mandibles with a rather shallow but continuous median groove. Pronotum with its transverse carina usually complete, though weakly developed; punctures of variable size, secondaries not well differentiated from primaries; primary punctures densely grouped in a very distinct though irregular discal band and in a small medial patch, on each side of which they become somewhat smaller and less dense; punctures in angle of discal band just anterior to tegula approximately the same size as others in the band; punctures in lateral disk largely true secondaries. Sides of pronotum with a definite groove across center merging with less conspicuous anastomosing grooves anteriorly; conspicuously striate on ventral corner, with a few punctures along dorsal border. Metanotum usually with a shallow median impression; posteriorly beset with dense primary and secondary punctures, the larger punctures not nearly so large as those of the scutellum. Legs with major calcarium of hind tibia having a distinct bend near middle, where calcarium is slightly wider than at base; hind basitarsus with a groove and with 3 or 4 lanceolate spines on the outside, one of which is apical. Tegula with inner hind corner not produced in a broad angle, sparsely hairy, with no hairs extending far above tegula when viewed from the opposite side; with a short, shallow impression on the outer anterior margin. Wings smoky; first cubital mark vaguely defined. Propodeal areola with sides nearly parallel, two to two and one-half times as long as wide; its carinae narrow, bordered by well developed grooves; median carina well developed but ending just before posterior margin. Lower portion of sides of propodeum mostly shagreened, without any patch of very fine hairs posteriorly. Propodeal slope without any well-defined punctures; median carina broadly flattened on top and extending over lower four-fifths. Transverse preapical band of first tergite at most one puncture wide, sometimes with small impunctate space medially, becoming wider laterally, not in a depression, most of the punctures separated. First sternite with lateral grooves on posterior half or less, with shallow punctures extending from anterior angle along sides of disk to vicinity of ends of lateral grooves. Tergites 3 to 5 with punctures noticeably farther from apex medially than laterally, where impunctate width is from two to four times the diameter of the largest adjacent punctures. Pygidium reticulato-punctate on basal three-



fifths; impunctate portion with numerous wrinkles nearly to apex, wrinkled portion also shagreened. Length 9.5 to 12 mm.

MALE.—Vertex with secondary punctures adjacent to occipital declivity forming a dense patch almost as wide as base of ocellar triangle; primary punctures penetrating ocellar triangle from behind, where they are of first-degree density; punctation each side of ocellar triangle of third-degree density except in a line along eye orbits, where they are of first-degree density. Front faintly shagreened in strong light; primary punctures on lower front very sparse medially, increasing in density toward the eye orbits, where they are at least as numerous as the secondaries; preocellar area with interspaces at least as broad as an ocellus; secondary punctures forming a dense patch on lower third, from which they extend upward in diminishing numbers, this decrease being more pronounced medially than in the region about the eye. Median groove present. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-sevenths to two-thirds as great as distance from apex of clypeus to edge of antennal fossa; apex slightly emarginate, with its impunctate margin lightly shagreened. Antennæ wholly black. Pronotum not shagreened; punctures mostly of third-degree density; secondary punctures sparse and widely scattered, slightly more numerous in a broken line just posterior to transverse carina; sides of pronotum with strong central groove frequently interrupted, sides above groove impunctate, finely and uniformly striate. Mesepisternum with its clearly defined primary punctures everywhere of third-degree density; secondary punctures much more numerous than primaries, and densely intermingled with them; premarginal groove along posterior surface lacking except on basal fifth, where it is definite but not deep. Scutellum with impunctate apex at least as wide as diameter of apical primary punctures. Metanotum densely punctate, with primary punctures nearly as large as those of the scutellum. Tegula black and polished but in strong light showing faint longitudinal striations, not shagreening; inner angle of posterior margin with definite groove formed by faintly depressed area. Wings with radial cell usually equaling second cubital cell in apical extension. Propodeum with its areola one and one-fourth times as long as wide, its sides straight but convergent posteriorly, the median carina heavier than the lateral carinæ and flattened on top, ending before apex of areola, enclosed area irregularly and transversely rugose and granulate, lower portion of sides densely shagreened; posterior aspect granulate, the minute punctures poorly outlined, median carina present on lower half or more. First tergite with preapical band wide, its anterior margin abruptly impressed, expanding somewhat laterally, punctures well differentiated only on posterior border. First sternite with posterior half of disk polished, lateral grooves on lower half or less, anterior angle with short median keel flanked by deeply crenulate grooves, numerous large, shallow punctures scattered over anterior half of disk and nearly meeting anterior end of lateral grooves. Tergites 3 to 5 shagreened, punctures deep and clearly defined, impunctate margins absent or at most no wider than the diameter of largest adjacent primary punctures. Denticle of fifth sternite of usual size and shape. Length 8.5 mm.



DISTRIBUTION.—Oita-ken, Kumamoto-ken, Miyazaki-ken, and Kagoshima, Kyushu; Nagano-ken and Gifu-ken, Honshyu.

TYPE AND ALLOTYPE.—Cat. No. 51090, U. S. National Museum. Type, female, Kagamigahara, Gifu-ken, Japan, September 30, 1931; allotype, male, Kagamigahara, Gifu-ken, Japan, October 1, 1931 (H. Sugiura).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Ueda, Nagano-ken, Honshyu, Japan, September 9, 1931 (H. Sugiura). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: One female and one male, Kagamigahara, Gifu-ken, Honshyu, Japan, October 1, 1931 (H. Sugiura).

Closely allied to *T. ovinigris* and *T. phyllophagæ* in general diagnostic characters as set forth in the key by Allen and Jaynes, *T. mediocris* was at first suspected of identity with *ovinigris* but a close study revealed a number of characters sufficiently different from those of either *ovinigris* or *phyllophagæ* to justify its recognition as a new species. Since the male of *T. ovinigris* is not known, it is possible, as exemplified by other species closely related to one another, that the male of that species may, when described, be inseparable from that of *T. mediocris*. In the female of *T. mediocris* the lateral grooves on the first sternite are confined to the posterior half or less; the median carina of the propodeal areola is bordered by deep grooves; the outer anterior margin of the tegula is not produced and has no tendency to upcurling but shows a short, poorly defined impression. These characters differ from those of *T. ovinigris* in that the lateral grooves on the first sternite of the latter are complete to near its anterior apex, and the outer anterior margin of the tegula is slightly produced, has a tendency to upcurling, and is devoid of any impression.

The apex of the clypeal extension in the male of *T. mediocris* is acutely though not deeply emarginate, and the lower half of the front very lightly shagreened. In *T. phyllophagæ* the apex of the clypeal extension is shallow and roundly emarginate, and the lower half of the front is devoid of shagreening.

*T. mediocris* has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 27.

***Tiphia burrelli* new species**

FEMALE.—Vertex with several patches of primary punctures of first-degree density, the largest extending upward from occipital region and invading ocellar triangle; secondaries scattered sparsely over dorsum; usually with minute punctures intermingled with primaries extending in an irregular linear series upward toward ocelli from occipital region. Front with primary punctures of first-degree density on lower half, upper half of mixed second-degree and third-degree punctation except along upper orbits, where punctures are of first-degree density, at times coalescing. Antennocular distance one and one-half times width of antennal fossa. Clypeus with its impunctate longitudinal extension about two-fifths as great as the distance from its apex to the edge of the antennal fossa. Mandibles without median groove. Antennae fulvous beneath. Pronotum with its transverse carina complete though not strongly developed; dorsum not shagreened and with fairly well differentiated transverse discal band of punctures; primary punctures sparse, everywhere anterior to the transverse discal band except for a medial patch where density is of first degree to second degree; punctures on lateral disks sparse and largely secondaries. Side of pronotum with a definite groove across its center, polished but finely striate above, a few well defined punctures occurring on anterior half. Scutum with its notauli and antero-medial groove nearly continuous. Metanotum beset with primary and secondary punctures, its largest punctures nearly as large as those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with a deep groove, and with 3 to 4 lanceolate spines on the outside, one of which is apical. Tegula black, polished, and with inner posterior angle produced and densely pilose, with several suberect hairs arising above tegula when viewed from across the dorsum. Wings smoky; first cubital mark vaguely defined; second intercubital vein sinuous; stigma about twice as long as wide, its posterior angle truncate and not produced. Propodeal areola with sides nearly parallel; median carina complete and bordered by shallow crenulate grooves; enclosed area uniformly granulate. Lower portions of sides of propodeum shagreened and bearing dense minute hairs. Posterior aspect of propodeum with median carina not broadly flattened, extending upward over lower half or more. First abdominal tergite with a preapical band of punctures one to two punctures wide at center, widening laterally into depressed patches of coalesced punctures; hindmost punctures only, in band, differentiated. Anterior slope of first tergite devoid of medial patch of minute punctures. First sternite with lateral grooves on posterior half; lacking any definite median keel. Second and third tergites with punctures on dorsum at most but little farther from apex medially than on either side; impunctate band two to three times as wide as diameter of adjacent primary punctures. Pygidium densely reticulato-punctate on basal three-fifths; with deep impunctate emargination from the impunctate apex. Length 15 to 16 mm.

MALE.—Vertex with primary punctures denser in a patch which invades ocellar triangle from behind than on either side. Front shagreened. Pri-

mary punctures in preocellar area of third-degree density, with one or more interspaces at least as wide as an ocellus, primaries becoming more numerous toward orbits, where density is of first degree; lower front with primary punctures gradually diminishing in size but without a well defined bipunctate area, punctures of uniform first-degree density over entire lower half except on slope bordering antennal fossa above. Antennocular distance slightly less than width of antennal fossa. Clypeal extension protruding, deeply emarginate, lacking any well defined impunctate margin; disk almost flat; apical width about four-fifths as great as distance from apex to edge of antennal fossa. Pronotum with dorsum shagreened; primary punctures everywhere of uniform third-degree density except in angle just anterior to tegula, where density is of second degree; secondary punctures not numerous, sparsely scattered among primaries. Side of pronotum with a well defined groove across the center, faintly striate but devoid of other sculpturing. Mesepisternum with primary punctures large and clearly outlined; secondaries less numerous than primaries everywhere except on posterior slope. Scutellum with very narrow, irregular, impunctate apical margin except for medial impunctate emargination one and one-half to two times as long as width of largest primaries. Metanotum convex, beset with primary and secondary punctures, with largest primary punctures definitely smaller than those of the scutellum. Tegula black, shagreened, with impressed line on lateral and posterior margins. Wings slightly smoky, radial cell exceeding second cubital cell. Propodeum with sides of areola parallel or nearly so, one and one-half times as long as wide; median carina incomplete and bordered by shallow grooves, enclosed area granular-reticulate; lower portion of sides of propodeum striate, a patch of microscopic hairs on posterior half; posterior slope with dense, fine, white hairs, median longitudinal carina confined to lower half or less. First tergite with its transverse band wide, poorly defined, in a broad, scarcely perceptible depression the anterior margin of which is abruptly impressed, punctures for the most part well separated. First sternite with posterior groove faintly crenulate; lateral grooves extending forward over posterior half, enclosed disk impunctate and highly polished; anterior half with median keel bordered by coarse poorly defined grooves and surrounded by coarse punctures. Tergites 3 to 5 with punctures vaguely outlined; no perceptible impunctate margins. Denticle on fifth sternite small. Hypopygium with its impunctate median stripe linear to its anterior extremity, where it tapers to a point. Length 10 to 11.5 mm.

DISTRIBUTION.—Gifu-ken, Hyogo-ken, Shizuoka-ken, Honshyu, Japan; Kagoshima-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51091, U. S. National Museum: Type, female, Kagamighara, Gifu-ken, September 25, 1932 (S. Fujii); allotype, male, Kagamigahara, Gifu-ken, September 17, 1932 (S. Fujii).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Kagamigahara, Gifu-ken, September 25, 1932 (S. Fujii). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: Two females, Kagamigahara, Gifu-ken, September 25, 1932, one male, Kagamigahara, Gifu-ken, September 17, 1932 (S. Fujii).

The character differences between *T. burrelli* and its nearest known relative, *T. vernalis*, are more pronounced than is the case with any of the other six species described in the present paper. The female of *T. burrelli* may be from 15–16 mm. in length, the pronotum devoid of median longitudinal grooves on its impunctate apex but provided with deep strongly curved grooves on its sides. In *T. vernalis* the female is approximately 11 mm. long, has one or more short, indistinct, median, longitudinal grooves on the impunctate apex of the pronotum, and it is provided with numerous striæ in the upper half of sides of pronotum but lacks a definite groove.

In the male *T. burrelli* has a sharply and irregularly impressed area anterior to the lateral portions of the transverse band of punctures on the first tergite, and the tegula is distinctly shagreened; in *T. vernalis* the male exhibits neither the sharply impressed area anterior to the transverse band of punctures on the first tergite, nor shagreening on the tegula.

*T. burrelli* has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohoma Laboratory Sp. No. 28.

#### ***Tiphia castaneaevora* new species**

FEMALE.—Vertex with a few series of punctures of second-degree density invading ocellar triangle from behind, primaries denser medially than either side. Front highly polished; groove present though frequently interrupted; primary punctures sparse, denser on anterior third, where they are evenly distributed between the eyes, chiefly of second-degree density except across expanse of upper front, where density is of third degree. Impunctate apex of clypeal extension poorly defined by a row of coarse punctures, its longitudinal extension about one-third the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Pronotum with its primary punctures nearly uniform in size; no definite transverse discal row or medial patch of punctures; secondary punctures sparse but well differentiated, widely scattered; medial longitudinal extension of punctate area slightly less than that of impunctate area. Side of pronotum without a



groove across the center, but with striations in this region sometimes increased to short, shallow, irregular grooves. Scutum with its notauli and antero-medial groove continuous or nearly so. Metanotum densely beset with primary and secondary punctures on its periphery, with its largest discal punctures much smaller than those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with groove, shallow and extending about one-half the length of joint, a group of three lanceolate spines on outside, one of which is apical. Tegula dark red and usually translucent on posterior half. Wings slightly smoky. Propodeal areola almost rectangular, two and one-half to three times as long as wide; carina narrow and uniform, bordered by conspicuous grooves; median carina on lowest three-fourths or complete. Lower portion of sides of propodeum shagreened, with patch of microscopic, appressed hairs. Posterior aspect of propodeum usually with scattered punctures antero-medially; median carina weak and flattened, sometimes complete. First abdominal tergite with pre-apical band of punctures narrow, at most slightly depressed medially, becoming more deeply depressed toward lateral extremities, where anterior margin becomes abruptly impressed, punctures usually coalesced. First sternite with lateral grooves on posterior half, and a few scattered punctures anteriorly. Tergites with polished impunctate margins medially about three to four times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half, with polished impunctate emarginations; apex scarcely wrinkled, and not shagreened. Length 8 to 9 mm.

MALE.—Vertex with primary punctures everywhere of third-degree density. Front with rather small primary punctures, lacking usual patch of punctures on lower front; preocellar patch on upper half very wide, with primary punctures of irregular second-degree and third-degree density and with interspaces broader than an ocellus; secondary punctures very dense below, not well differentiated from primaries on area where both primaries and secondaries occur, ascending half way to lowest ocellus medially and about one-third of the way along the eyes. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-fifths as great as the distance from apex of clypeus to edge of antennal fossa; disk flat and not protruding; apex shallowly emarginate, lacking an impunctate margin, but with a thick edge. Pronotum with primary punctures small, fairly well outlined, largely of third-degree density; a few secondary punctures close to carina. Sides of pronotum finely striate, without a definite medial groove. Mesepisternum with small, sparse, well outlined primary punctures; secondary punctures dense on upper half and bordering the prepectus and posterior margin, less numerous than primaries only on the small callosity above the coxa; no premarginal groove, though appearing shallowly impressed in certain lights. Scutellum, except medially, with impunctate apex not as wide as largest apical primary punctures. Metanotum with dense secondary punctures apically, elsewhere with sparse primaries nearly equaling the largest of the scutellum in size. Tibiæ and tarsi of first two pairs of legs mostly reddish. Tegula polished, translucent, red. Wings with radial cell slightly

exceeding cubital cell. Propodeum with areola rectangular in outline, nearly twice as long as wide, lateral carinae without bordering grooves, the median carina sinuous, the enclosed area somewhat rugose. Side with lower region not punctate or hairy but finely shagreened; posterior aspect densely hairy, with a median carina on lower half. First tergite with preapical band narrow, deeply impressed, of nearly uniform width, its punctures fading out on surface of depression. First sternite with lateral grooves on posterior third; disk with vague punctures and a sharp median keel anteriorly. Tergites 3 to 5 moderately shagreened, with punctures extending to apex. Fifth sternite with its lateral denticle appearing more like a crescent than a tooth. Length 6.5 to 7 mm.

DISTRIBUTION.—Chiba-ken, Tokyo-fu, Honshyu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51092, U. S. National Museum: Type, female, and allotype, male, Tachikawa, Tokyo-fu, Japan, June 11, 1932.

PARATYPES.—Deposited in the collection of the U. S. National Museum: Two females and two males, Tachikawa, Tokyo-fu, June 11, 1932. Deposited in the collection of the Academy of Natural Sciences of Philadelphia: Three females and three males, Tachikawa, Tokyo-fu, June 11, 1932. Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: Three females, Tachikawa, Tokyo-fu, June 11, 1932; and three males, Narashino, Chiba-ken, June 9, 1932 (S. Fujii).

This species is very closely related to *T. asericæ* A. and J. The distinguishing character in the female is the preapical band of punctures on the first tergite. In *T. asericæ* this band is sharply depressed throughout its length, while in *T. castaneævora*, n. sp., the band is depressed very little if at all medially but becomes more abruptly depressed toward its lateral extremities. The writer has not been able to find any reliable character for separating the males of the two species, though there are minor differences that, while they defy description, can be used comparatively with a fair degree of accuracy.

*T. castaneævora* has been previously known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 29.

## THE GENUS STENOPOGON LOEW IN THE UNITED STATES OF AMERICA (ASILIDÆ: DIPTERA)

BY STANLEY W. BROMLEY, PH.D.

Since the appearance of my key to this genus in the Annals of the Entomological Society of America, Vol. XXIV, 2, June, 1931, I have examined a large amount of material which has resulted in the addition of nineteen new species. One of these—*S. kelloggi* was described by Mr. Joseph Wilcox. I have incorporated his description in this paper. I have further revised the key to include these new species and to elucidate relationships. I am particularly grateful to Mr. Joseph Wilcox, of Puyallup, Washington, for furnishing me material and many helpful suggestions and to Mr. E. C. Van Duzee, of the California Academy of Sciences, San Francisco, Calif., for loaning material from the Academy collection. I wish to thank also, Mr. E. S. Thomas, Curator of Natural History of the Ohio State Museum, Columbus, Ohio, for allowing me the study of the Hine collection.

*Stenopogon* contains many species from western North America. Only one species occurs east of the Mississippi. Most are rather elongate, small-headed Robber flies. In habits, they are ravenous, feeding on insects quite large in proportion to their size; some, as *S. obscuriventris*, *S. rufibarbis*, *S. timberlakei*, *S. gratus*, and *S. inquinatus*, preying extensively on honey-bees. In Texas, *S. latipennis*, is said by Mr. H. B. Parks to be destructive to the hive-bee, also. The species of *Stenopogon* themselves are likely to be preyed upon by more powerful asilids, particularly the fierce *Diogmites*, which are in turn frequently captured and killed by the large species of *Proctacanthus*.

The genus *Stenopogon* as here treated contains as a subgenus *Scleropogon* Loew. While some workers consider the two genera distinct, the species of both groups are so similar in most respects and the characters on which separation is based are so trivial that I do not think a split is justifiable.

*Ospricerus* Loew is closely related to *Stenopogon*. Separation of these two genera has been based largely on the length of the

third antennal segment and the fact that in *Ospricerus* this segment usually lacks the terminal style. The latter character is however not tenable: *O. diversus* Williston has a minute style, while *O. eutrophus* Loew has a distinct demarkation at the tip of the third antennal segment. In *O. ventralis* Coquillett, the minute style is inset in the third antennal joint. The only stable character that I have found to satisfactorily separate the genera is the length of the third antennal segment. In all species of *Ospricerus* that I have seen, the third antennal joint is three times the length of the first two together, quite appreciably longer than in any *Stenopogon* I have examined. On this basis, *Stenopogon nitens* Coquillett should rightfully belong in *Ospricerus*. I have examined Coquillett's type at the National Museum and found that *S. nitens* Coq. is identical with my *Ospricerus monki* (Jour. N. Y. Ent. Soc., XLII, p. 225, June, 1934). *Ospricerus monki* Bromley therefore becomes a synonym of *Ospricerus* (*Stenopogon*) *nitens* (Coq.).

GENOTYPE: *Asilus sabaudus* Fabricius, Entomol. System., IV, 385, 40 (1794). Central and South Europe.

#### KEY TO STENOPOGON SPECIES

1. "Hypopleura"\* bare ..... 2
- "Hypopleura" with hair or bristles (subgenus *Scleropogon*) ..... 23
2. Very small species (10-13 mm.) (California); third antennal joint somewhat oval; arista short and bristle-like; wings short and narrow ..... 3
- Larger, more robust species; third antennal joint constricted apically; arista not so sharply differentiated ..... 4
3. Black species ..... *nigritulus* Coq.
- Yellowish-brown species ..... *albibasis* Bigot
4. Mystax at least partly black, usually entirely so or the upper half black ..... 5
- Mystax nearly, usually entirely, light-colored ..... 8
5. Mystax all black ..... 6
- Mystax partly light-colored ..... 7
6. Bloom of mesonotum pale gray; pile of front coxæ, fore femora, beard and post-genæ straw-colored; all tibiæ darkened at tip; genitalia slightly enlarged (16-26 mm.) (California) ..... *jubatus* Coq.
- Bloom of mesonotum brown; a darker-colored species than *jubatus* with more black hairs and bristles, the posterior portion of the mesonotum

\* The small calloused sclerite immediately anterior to the halteres. This plate is really the katapleurotergite of the postscutellum. It is the "hypopleura" of Back, not Williston.



- bearing mostly black hairs; the pile of the front coxæ, fore femora, beard and post-genæ white (20-21 mm.) (California) *..jubatoides* n. sp.
7. *Mystax* black above, rest reddish-yellow (male); female with *mystax* mostly black; first two antennal joints together shorter than third; pile on sides of abdomen yellow; genitalia small, compact (18-20 mm.) (Mexico, Lower California) *.....stonei* n. sp.
- Mystax* black only in extreme upper portion, rest yellowish; hair along sides of abdomen whitish; abdomen black, shining; only female known (21-22 mm.) (California) *.....nigroverticellus* n. sp.
8. *Sternopleura* with a tuft of long fine pile; smaller species .....9  
*Sternopleura* without such a tuft although usually with some pile; large variable, robust species, with or without red on abdomen (20-37 mm.) (Western U. S.) (= *modestus* Loew and *morosus* Loew).  
*.....inquinatus* Loew
9. Vestiture of thorax light-colored; hairs coarse; wings small .....10  
Some black hairs at least on dorsum of thorax; wings larger .....12
10. Vestiture straw-colored .....11  
Vestiture of head and thorax reddish-yellow; male genitalia dark reddish, small, compact, forceps short not bent (16-19 mm.).  
*.....propinquus* n. sp.
11. Male genitalia large, bulging, the upper appendages bent downward at tips, the lower bent upward at tips (15-22 mm.) (California).  
*.....breviusculus* Loew
- Male genitalia short, compact; abdomen shorter and stouter than in the case of *breviusculus* (16-21 mm.) (California). *.....breviusculoides* n. sp.
12. Dorsum of abdomen reddish or yellowish on most segments .....21  
Abdomen blackish on dorsum, except sometimes slightly reddish on last two segments (*obscuriventris* group) .....13
13. Robust, unusually coarsely hairy species, particularly of thorax and base of abdomen, the hairs and bristles of which are thick, straw-yellow; all tibiæ blackish at apex (not so pronounced on first and second pairs in some females); male genitalia black, small, compact (22-24 mm.) (Coronado, California) *.....felis* Bromley
- More slender and elongate species, not so coarsely hairy .....14
14. Posterior aspect of middle femur, except extreme base, reddish-yellow; abdomen shining black, very sparsely gray pollinose;\* male genitalia enlarged, black, pale-haired; posterior tibiæ blackish on distal portion; first two pairs of tibiæ entirely yellowish (21-27 mm.) (Southern California) *.....Wilcoxi* n. sp.
- Posterior aspect of middle femur, except tip, black .....15

\* Throughout this paper, as well as in all my previous papers, the term "pollinose" is used in the same sense as that described by Curran in his Glossary of Terms used in Dipterology (The Families and Genera of North American Diptera, 1934, p. 489) and means "covered with 'dust' or 'bloom.' " The term does not imply a yellowish or any other color.

15. Vestiture of head, thorax, legs and base of abdomen largely reddish or reddish-yellow; pollen of abdomen brownish-gray .....16  
 Vestiture of head, thorax, legs and base of abdomen straw-colored .....17
16. Male genitalia dark reddish, compact; all tibiae reddish; (18-23 mm.)  
 (Calif., Wash., Ore., Utah) .....*rufibarbis* Bromley  
 Male genitalia enlarged, black; hind tibiae blackish at extreme tip (18-26 mm.) (Calif.) .....*rufibarboides* n. sp.
17. Mesonotum more or less brownish pollinose .....18  
 Mesonotum more grayish pollinose .....20
18. Abdomen largely shining black with a faint blue-gray bloom; many black hairs and bristles on posterior portion of mesonotum and scutellum; posterior tibia with the distal two-thirds black; male genitalia solid black with upper forceps turned downward at tip; a small dark colored species (15-17 mm.) (California) .....*engelhardti* n. sp.  
 Abdomen either pale brown or yellow-gray pollinose .....19
19. Abdomen pale brown pollinose; all tibiae usually yellowish, occasionally the posterior darkened toward the tip; male genitalia compact, usually dark reddish to reddish-brown in color (16-26 mm.) (Western U. S.).  
*obscuriventris* Loew  
 Abdomen faintly and thinly pale yellow-gray pollinose; male genitalia small, black, compact; tips of tibiae dark brown or blackish, the first two pairs in the female not always darkened (19-23 mm.) (Southern Calif.) .....*andersoni* n. sp.
20. Gray pollinose; large elongate species; male genitalia black or very dark brown; tips of all tibiae darkened (22-27 mm.) (California).  
*timberlakei* n. sp.  
 Abdomen densely light gray pollinose, smaller species; male genitalia yellowish to yellowish-brown, compact; pollen of thorax generally slightly more brownish than that of abdomen; posterior half to quarter of hind tibiae blackish, others all yellowish (16-23 mm.) (Western U. S., Kansas to Calif.) .....*martini* n. sp.
21. Robust species; male largely reddish-haired, vestiture of female more straw-colored; usually only broad dorsal line of abdomen reddish, sides black (15-25 mm.) (Calif.) .....*gratus* Loew  
 More slender species; light vestiture straw-colored .....22
22. Usually entire dorsum of abdomen reddish or yellowish; upper forceps of male genitalia from side-view with inner prongs extending beyond tip (15-27 mm.) (Calif.) .....*californiae* (Walker)  
 Upper forceps of male genitalia from side-view with no prongs extending beyond tip (19-24 mm.) (Calif.) .....*californioides* n. sp.
23. Third antennal joint long; style short and compact; first posterior cell usually open .....24  
 Third antennal joint shorter; style bristle-like .....32
24. Wings black; decidedly black species with red on abdomen, the latter not obscured by a grayish bloom, but the tip and base are black (14-20 mm.) (Kans., Colo., Nebr., Texas, Mont.) .....*exacidinus* Williston

- Wings grayish, reddish or brownish, not deep black; reddish or blackish species, if the latter, the abdomen obscured by bloom ..... 25
25. Blackish species, gray pollinose ..... 26
- Reddish species ..... 28
26. Short, stout species; wings gray with costal area yellowish-gray (14-17 mm.) (Texas, Kansas) ..... *pumilus* Coq.
- Larger, more elongate species ..... 27
27. Hairs on mesonotum all pale; wings gray subhyaline, pale brownish near veins; third segment of antenna narrowed toward tip and with a longitudinal seam on lower distal portion (21-25 mm.) (Arizona and New Mexico) ..... *arizonensis* n. sp.
- Mesonotum with some black hairs on median dorsal area; wings uniformly grayish-brown; femora mostly blackish, the front with a reddish-yellow vitta on forward side (22-26 mm.) (Texas and New Mexico.)
- \**tenebrosus* Coq.
28. Elongate species ..... 29
- Shorter, stouter species ..... 30
29. Third antennal segment about as long as first two together; reddish-yellow species; abdomen quite slender, subpolished; wings broader than in next species, uniformly brownish or blackish (darkest in the specimens from the Southeastern U. S.); bristles and hairs of entire body sordid white, those on vertex and legs more yellowish (20-27 mm.) (Southeastern U. S. from N. Carolina to Texas and Colorado).
- subulatus* (Wiedemann)
- Third antennal segment almost twice as long as first two together, abdomen unusually slender; wings long and narrow; hairs and bristles yellowish; humeri, abdomen and legs light reddish-yellow; each femur with a basal black spot; thorax blackish, yellow pollinose; wings yellowish-gray (17-20 mm.) (Texas and New Mexico) ..... *longulus* Loew
30. Thorax grayish-yellow pollinose ..... 31
- Thorax reddish-yellow pollinose; rather large robust species; bristles of body golden; femora stout (18-21 mm.) (Texas, New Mexico, Colorado) ..... *latipennis* Loew
31. Legs all pale reddish; some black bristles on hind femora, tibiae and vertex of head; small pale species (15-16 mm.) (Rio Grande Valley of Texas) ..... *ebyi* n. sp.
- Black vitta on hind femora; hind femora and tibiae without black bristles; larger stouter species (15-19 mm.) (Nebraska, South Dakota, Colorado) ..... *consanguineus* Loew
32. First posterior cell closed (occasional specimens of *indistinctus* n. sp. have this cell slightly open) ..... 33
- First posterior cell wide open ..... 42
33. Wholly and densely gray-white or white pollinose (the male white; the

\* My previous *Stenopogon* keys, based on a misidentification of *tenebrosus*, do not run to this species correctly.

- female gray or pale yellowish); wings hyaline; a slender elongate species with small wings (15–20 mm.) (Texas) ..... *cinerascens* Back
- Not densely white pollinose ..... 34
34. Wings spotted with fuscous; large, yellow pollinose, robust Mexican species (20–30 mm.) ..... *truquii* Bellardi
- Wings not spotted ..... 35
35. Small, slender species; abdomen in male dull black, in female reddish above (19–20 mm.) (Arizona) ..... *dispar* n. sp.
- Sexes similar; abdomen pollinose ..... 36
36. Abdomen and legs entirely reddish-yellow; small species (15 mm.) (New Mexico and Arizona) ..... *kelloggi* Wilcox n. sp.
- Legs with some black and ground color of abdomen with some black, if only mid-dorsal line ..... 37
37. Chamois leather-yellow species, the abdomen pale in ground color with only a mid-dorsal line of black (tergites with blackish anterior areas in *uhleri*) ..... 40
- Abdomen with more black in ground color ..... 38
38. Abdomen banded with black above, the segments black with posterior margins and venter red; yellowish-gray pollinose species (20–28 mm.) (Calif., Arizona, New Mexico) ..... *picticornis* Loew
- Abdomen more pollinose, the black portions less conspicuous ..... 39
39. Thorax grayish-yellow pollinose contrasting with abdomen which is grayish pollinose; ground color of abdomen more or less blackish; first antennal segment yellowish; a small rather robust species (15–19 mm.) (Montana, Nebraska, Colorado, Alberta) ..... *coyote* Bromley
- Grayish-yellow pollinose species with abdomen and thorax not so contrasting; abdomen proportionately longer and more slender than *coyote*; the first posterior cell closed at margin or slightly open (19–26 mm.) (Arizona, Oklahoma) ..... *indistinctus* n. sp.
40. “*Hypopleura*” with stout bristles ..... 41
- “*Hypopleura*” with short, fine hair; antennæ black; wings hyaline; legs dark, some reddish on front and middle femora; male ventral plate divided at tip and lobes divergent (first and fourth posterior cells closed and petiolate (23 mm.) (Colorado) ..... *uhleri* Banks
41. Style of antenna  $\frac{1}{2}$  length of third joint (20–30 mm.) (Texas, Kansas, Nebraska) ..... *helvolus* Loew
- Style equal in length to third joint (24 mm.) (Nebraska) ..... *similis* Jones\*
42. Brown and flesh-colored species, densely covered with gray and yellow pollen (20–23 mm.) (Mexico) ..... *mexicanus* Cole
- Reddish or blackish species ..... 43
43. Thorax reddish with black longitudinal lines on mesonotum; wings blackish, reddish toward base; reddish species (18–23 mm.) (Texas).
- texanus* Bromley
- Thorax mostly blackish, grayish or yellowish pollinose; wings more hyaline ..... 44

\* I have not seen this species, but infer from the original description that it should fit here.



44. Robust species; mesonotum gray pollinose .....45  
 Slender, elongate species; thorax with pale yellow pollen; abdomen gray  
 pollinose; genitalia reddish; antennæ all black (17-22 mm.) (New  
 Mexico and Arizona) ..... *duncani* n. sp.
45. Black species; abdomen mostly blackish (19-28 mm.) (Wyoming, Idaho,  
 Colorado, Washington, Oregon, Utah) ..... *neglectus* Bromley  
 Black species; abdomen mostly reddish above (26-29 mm.) (California).  
*bradleyi* n. sp.

I am unable to definitely separate *inquinatus* Loew, *morosus* Loew and *modestus* Loew and prefer, for the present, to consider them all as one variable species. The males are likely to have the abdomen reddish above and the front femora reddish below and anteriorly and are thus typical *inquinatus*. Then there are gradations from abdomen partially red (*morosus*) to blackish gray (*modestus*); *modestus* and *morosus* typically have the wings light grayish brown and the front femora largely, except the tip, blackish brown. In addition, there are some male specimens of *inquinatus*, *morosus* and *modestus* which have the wings more or less whitish. I can find no striking differences in the male genitalia. *Inquinatus* is evidently a widespread common species with varying color phases, as is exhibited in several other Dasypogonine forms, i.e., *Dizonias tristis*, *Sarapogon dispar*, *S. combustus*, *S. abbreviatus*, and *Microstylum morosum*.

#### ***Stenopogon jubatoides* new species**

Total length, 20-21 mm. A dark-colored species closely related to *jubatus* Coquillett from which it may be distinguished by the general darker color, the posterior portion of the mesonotum bearing mostly black hairs, the bloom of the mesonotum brown, not pale gray, and the pile of the front coxæ, fore femora, beard, and post-genæ white, not straw-colored.

MALE. Face pale brown pruinose. Mystax and hairs of vertex black. Pile of occiput, post-genæ and beard white. Thorax with brownish bloom; most of hairs of dorsal and posterior portions of mesonotum and scutellum black, a few whitish hairs on sides. Legs black; tips of femora, basal fourth of tibiæ and tarsal segments, except extreme tips, pale reddish-yellow. Hairs of front coxæ and fine pile on femora white. Wings with bases milky-white, elsewhere gray subhyaline, the venation accentuated with pale brownish. Abdomen shining black with fine white hairs along sides, mid-dorsal line with blackish hairs. Genitalia black with some brownish and some white hairs.

FEMALE. Similar, ovipositor with pale brown bristles.

Holotype, male, Mt. Diablo, Calif., July 21, 1935 (Jack Beamer) [Kans. Univ. Coll.]. Allotopotype, female, same data. Paratopotype, same data.

**Stenopogon Stonei** new species

Total length, 18–20 mm. A black species related to *jubatus* Coq., with the mystax black above and reddish-yellow below in the male; the mystax of the female mostly black, the first two antennal joints together shorter than the third; the pile on the sides of the abdomen yellow; the wings smoky-brown, the anal angle white in the male.

MALE. Face gray pollinose. Mystax (lower  $\frac{3}{4}$ ths), beard and hairs of occiput reddish-yellow. Hairs of upper mystax, antennæ and vertex black. Thorax brown pollinose, mesonotum above with black lines bearing black hairs. Sides of mesonotum, the pleura and coxæ with golden hairs and bristles. Legs with golden hairs and bristles. Femora black with apices reddish; tibiæ reddish with black tips; tarsi and bases of claws reddish, the posterior tarsi with black tips to the segments. Wings smoky-brown, with anal angle whitish. Abdomen slender, black, shining, with golden hairs. Genitalia compact, black, with golden and some black hairs.

FEMALE. Similar, except mystax mostly black and abdomen lightly gray-brown pollinose.

Holotype, male, Ensenada, Mex., July 5, 1930 (M. W. Stone). Allotype, female, same data. Paratopotype, male, same data. [J. Wilcox Coll.]. This species was named in honor of the collector, Mr. M. W. Stone.

**Stenopogon nigriverticellus** new species

Total length, 21–22 mm. A black species related to *jubatus* Coq., differing in having the mystax, except the upper portion, yellow. The abdomen is shining black with whitish hairs along the sides.

FEMALE. Face grayish-yellow pollinose. Beard and mystax straw-colored. Upper portion of mystax, antennæ and vertex with black hairs. Occipital hairs sordid straw-colored. Thorax black, shining above, with scattered patches of gray pollen. Hairs on median area of mesonotum black; rest of thoracic vestiture pale straw-colored. Legs with whitish hairs and straw-colored bristles. Femora black with pale reddish tips; tibiæ pale reddish, extreme apices blackish except posterior pair, the distal half of which are black. Wings smoky subhyaline. Abdomen shining black with sordid whitish hairs.

Holotype, female, San Diego, Calif., July 7, 1929 (L. D. Anderson). Paratopotype, female, same data [J. Wilcox Coll.].

**Stenopogon propinquus** new species

Total length, 16–19 mm. A black species, reddish-yellow hirsute and pollinose, closely related to *breviusculus* Loew from which it is distinguished by the more reddish color of the hairs and the short, compact genitalia.

MALE. Face yellow-gray pollinose. Vestiture of head abundant, reddish-yellow. Thorax black, reddish-yellow pollinose with concolorous thickly set

reddish-yellow hairs. Wings hyaline. Legs reddish; femora black above and distal half of hind tibiae dark reddish-brown. Hairs and bristles of legs, reddish-yellow. Claws black with red bases. Abdomen reddish with reddish hairs; tops of first four segments blackish anteriorly. Genitalia dark reddish, small, compact.

Holotype, male, Pete's Butte, July 10, 1930 (Robert L. West). Allotype, female, San Diego Co., Calif., April 13, 1914 (E. P. Van Duzee). Paratopotypes, 2 males, Pete's Butte, July 10, 1930 (Robert L. West) [J. Wilcox Coll.]. Paratypes, 2 males, 1 female, San Diego Co., Calif., June 21, 1914, August 15, 1913, April 13, 1914 (E. P. Van Duzee); 1 male, 1 female, Mok. H. Calif., June 6, 1896 (F. E. Blaisdell); male, Milbrae, San Mateo Co., Calif., Sept. 1, 1912 (F. E. Blaisdell) [Calif. Acad. Sci. Coll.].

***Stenopogon breviusculoides* new species**

Total length, 16-21 mm. A yellowish pollinose, yellowish haired species very similar to *breviusculus* Loew, but distinguished therefrom by the shorter stouter abdomen and the entirely different male genitalia.



FIG. 1. Male genitalia of *breviusculus*.



FIG. 2. Male genitalia of *breviusculoides*.

**MALE.** Head gray-white pollinose; vestiture straw-colored. First two antennal joints reddish-brown, third blackish-brown. Thorax yellow-brown pollinose, vestiture concolorous. Mesonotum with three dark lines. Wings hyaline. Legs yellowish-brown with concolorous hairs and bristles; upper surfaces of femora and outer aspect of hind tibiae blackish. Abdomen comparatively shorter than in the case of *breviusculus*, yellowish-brown pollinose with concolorous vestiture. Ground color of abdomen blackish and reddish. Genitalia short, rather compact, upper forceps reddish.

**FEMALE.** Similar; ovipositor with reddish-brown bristles.

Holotype, male, Monterey, Calif., July 22, 1935 (Jean Russell). Allotopotype, female, same data. Paratopotypes, 2 males, 3

females, same data. Paratypes, 3 males, 5 females, Cuyama Ranch, Calif., July 25, 1935 (E. I. Beamer, R. H. Beamer, Jean Russell). Holotype and allotype in Kans. Univ. Coll., other types in Coll's. of S. W. Bromley, J. Wilcox and Univ. Kans.

***Stenopogon wilcoxi* new species**

Total length, 21–27 mm. An elongate black species of the *obscuriventris* group with the bases and posterior part of the wings in the male broadly whitish, unique in having the posterior aspect of the middle femora (except the extreme base) reddish-yellow. The abdomen is only sparsely gray pollinose, less so in the male where it is largely shining black. The male genitalia is somewhat larger than in *obscuriventris*, is shining black, but pale haired. The first two pairs of tibiae are entirely yellowish while the posterior is blackish on the distal portion.

MALE. Face gray pollinose. Vestiture of head, except the fine black hairs of antennae and vertex, pale straw-colored. Thorax with pale straw-colored pollen and fine hairs, except the fine black hairs along mid-dorsal area of mesonotum. Wings hyaline; anal angle and posterior base whitish. Legs with straw-colored hairs and pale reddish bristles; tarsi with a few black bristles. Legs reddish, the basal portions two thirds to three quarters of the femora black, except the posterior aspect of the middle femur which is largely reddish-yellow with the extreme base black. Tibiae and tarsi reddish-yellow, except tip of posterior tibia which is black and the tips of the posterior tarsal segments which are blackish. Abdomen elongate, shining black, with straw-colored hairs. The genitalia are blackish, rather large and bulging; the upper appendages curved inward and downward at tip, the lower turned up.

FEMALE. Similar, but the wings gray subhyaline and the abdomen more gray pollinose.

Holotype, male, San Diego Co., Calif., July 7, 1929 (R. H. Beamer). Allotype, female, same data. Paratopotypes, 4 males, 6 females, same data (P. W. Oman). Paratypes, 1 male, 2 females, San Jacinto Mts., Calif., July 21, 1929 (L. D. Anderson); 2 females, Laguna Mts., Calif., July 6, 1929 (L. D. Anderson and P. W. Oman) [Kans. Univ. Coll.]; 1 female, Cajon Pass, Calif., August 22, 1931 (C. H. Martin); 1 male, Pine Valley, San Diego Co., Calif. (W. J. Chamberlain) [Hine Coll.]; 2 males, 2 females, Warners, San Diego Co., Calif., July 26, 27, August 1 and 2, 1921 (James) [Colo. State College Coll.]; 6 males, 5 females, Campo, Calif., August 10, 1935 (Jean Russell and Jack Beamer), 4 males, 12 females, Idyllwild, Calif., August 3, 1935 (Jean Russell), 1 male, Anza, Calif., Aug. 6, 1935 (Jack Beamer),



4 females, Jacumba, Calif., Aug. 12, 1935 (Jack Beamer) [Univ. Kans. Coll.]; 1 male, Tahquitz Canyon, Riverside Co., Calif., June 27, 1928 (E. C. Van Dyke), 2 males, 4 females, Idlewild, Calif., June 29, 1928, July 5, 1928 (E. C. Van Dyke) [Calif. Acad. Sci.].

This species was named in honor of Mr. Joseph Wilcox, of Puyallup, Wash., who has been very much interested in the Asilidae.

***Stenopogon rufibarboides* new species**

Total length, 18-26 mm. Closely related to *rufibarbis* Bromley, but differs in having the male genitalia larger and shining black, not dark reddish.

MALE. Face gray pollinose. Vestiture of head reddish, except hairs of vertex which are blackish. Thorax black with a shining black median stripe. Mesonotum reddish-brown pollinose above, pleura gray pollinose. Wings pale brown subhyaline with anal angles whitish; base of costa with reddish-gold hairs. Coxæ and mesonotum with reddish hairs except those on median line which are black. Scutellars mostly reddish, a few black. Legs reddish-yellow with concolorous hairs and bristles; femora, except tips, black; hind tibiæ blackish at extreme tips. Abdomen elongate, slender, shining black, the incisures gray pollinose, the hairs red. Genitalia shining black with reddish hairs, enlarged and bulging, with upper appendages curving inward and downward at tip.

FEMALE. Similar, but wings all gray subhyaline, the abdomen with pollen more gray-brownish than in male. One or two black bristles in upper portion of mystax. Most of the reddish vestiture is paler than in the male.

Holotype, male, Sequoia Nat'l Park, Potwisha, Calif., 2000-5000 ft. alt., May 20, 1929. Allotopotype, female, same data (E. C. Van Dyke). Paratopotypes, 3 males, 4 females, May 12-29, 1929 (Calif. Acad. Sci.). Paratypes, 2 females, San Diego, Calif., Aug. 7, 1935 (Jean Russell) [Kans. Univ. Coll.].

***Stenopogon engelhardti* new species**

Total length, 15-17 mm. A small, rather dark-colored species closely related to *obscuriventris* Loew, but differs in having more black hairs and bristles on the posterior portion of the mesonotum and scutellum, the abdomen largely shining black with a faint blue-gray bloom, the posterior tibiæ with the distal two thirds black, and the male genitalia solid black with the upper forceps turned downward at the tip.

MALE. Vestiture of head golden straw-colored, except hairs of vertex which are black. Thorax shining black, with brownish pollen here and there, most of the bristles of mesonotum and scutellum black. Hairs of pleura and

coxæ pale golden. Legs black except tips of femora and the tarsi and tibiæ with the exception of the posterior tibiæ, which have the distal two thirds black, entirely reddish. Femora with fine whitish pile. Wings fumose, the extreme base and anal angle milky-white. Abdomen shining black with fine scattered whitish pile and indistinct light blue-gray bloom. Genitalia small, compact, shining black, the tips of the upper forceps turned downward.

FEMALE. Similar, but scutellum with several pale bristles in addition to the black. Wings paler and without white areas. Ovipositor with dark brown spines.

Holotype, male, Jacumba, Calif., April 26, 1935 (G. P. Engelhardt). Allotopotype, same data. [J. Wilcox Coll.].

This species is named in honor of the collector, Mr. G. P. Engelhardt.

***Stenopogon andersoni* new species**

Total length, 19–23 mm. Closely related to *obscuriventris* Loew, differing in having the tips of the tibiæ usually dark brown or blackish (the first two pairs in the female not always darkened), the abdomen having less pollen and that which is present of a yellow-gray color instead of pale brown, and the genitalia of the male smaller, more compact and black.

MALE. Face yellow-gray pollinose. Vestiture of head straw-colored. Thorax pale yellowish brown pollinose, vestiture straw-colored, a few black hairs on median line of mesonotum. Scutellum with pale straw-colored bristles. Legs with hair and bristles straw-colored. Wings gray subhyaline, very pale yellow-brown along vein margins, anal angle whitish. Femora, except apices, black; tips of tibiæ black; tips of segments of posterior tarsi black; rest of legs yellowish. Abdomen elongate, slender, dull black, sparsely gray-yellow pollinose with pale straw-colored hairs. Genitalia small, black, compact.

FEMALE. Similar, the abdomen more densely yellow-gray pollinose and anal angles of wings not decidedly whitish.

Holotype, male, San Jacinto Mts., Calif., July 21, 1929 (L. D. Anderson). Allotopotype, female, San Jacinto Mts., July 21, 1929. [J. Wilcox Coll.]. Paratopotypes, 2 males, same data; 1 female, June 30, 1933 (R. H. Beamer). Paratype, 1 male, Cuyama Ranch, Calif., July 25, 1935 (Jean Russell) [Kans. Univ. Coll.]. This species was named in honor of the collector, Mr. L. D. Anderson.

***Stenopogon timberlakei* new species**

Total length, 22–27 mm. A light gray pollinose elongate species of the *obscuriventris* group, having the male genitalia blackish, the tibiæ yellow with tips black.

MALE. Vestiture of head pale straw-colored. Thorax gray pollinose with pale straw-colored hairs, some black along median line of mesonotum. Wings gray subhyaline, anal angles white. Legs with straw-colored hairs and pollen, the tarsi yellow, the tibiæ yellow with black tips, the femora black with yellow tips. Abdomen elongate, black, gray pollinose. Genitalia black; in two of the paratypes dark reddish-brown.

FEMALE. Similar, anal angles of wings not white.

Holotype, male, Brentwood, Calif., June 12, 1925 (S. W. Bromley). Allotype, female, same data. Paratopotypes, 2 males, 3 females, same data. [S. W. Bromley Coll.]. Paratypes, 1 female, Saltdale, Calif., June 19, 1932 (A. T. McClay) [J. Wilcox Coll.]; male, Jacintos Barranca, Kettleman Plains, Fresno Co., Calif., June 4, 1907 (Bradley); male, Coalunga, Fresno Co., Calif., June 9, 1907, elev. 500 ft. (Bradley); male, Buena Vista Reservoir, Calif., April 27, 1917 [Hine Coll.].

Two of the Brentwood specimens were taken with prey: a honeybee and a Pentatomid bug. This species was named in honor of Mr. P. H. Timberlake of the Riverside Experimental Station who first called this species to my attention.

#### **Stenopogon martini** new species

Total length, 16-23 mm. A pale gray pollinose species related to *obscuriventris* Loew. The abdomen is densely light gray pollinose, the male genitalia compact, yellowish to yellowish-brown, the pollen of thorax slightly more yellowish or brownish than that of abdomen. The tibiæ are yellowish, except the posterior which has the distal quarter to half black.

MALE. Black; head gray pollinose. Vestiture pale straw-colored. Thorax yellowish or pale brownish gray pollinose, the disc of mesonotum pure gray pollinose. Mesonotum with a median blackish divided line. Vestiture of thorax and legs pale straw-colored; except some black hairs on disc of mesonotum. Legs reddish-yellow, the femora except tips, black; the posterior tibia with distal half blackish. Wings subhyaline, pale brown along veins, anal angle whitish. Abdomen black, gray pollinose with sordid white hairs. Genitalia compact, yellowish-red.

FEMALE. Similar, except anal angle of wings not white, and hind tibiæ black on only distal quarter. The abdomen more densely gray pollinose.

Holotype, male, Parma, Idaho, May 13, 1934 (C. H. Martin). Allotopotype, female, same data. Paratopotypes, 17 males, 18 females, same data. Paratypes; 3 males, Klamath Indian Reservation, Bly Mts., Ore., June 23, 1933 (G. P. Engelhardt); 1 male, Hermiston, Ore., May 10, 1930 (H. A. Scullen); 1 male, "P"

Ranch, Harney Co., Ore., June 27, 1922 (W. J. Chamberlain); 1 male, 1 female, Jefferson Co., Mont., July 8, 1924 (E24-38); 1 male, 1 female, Vantage, Wash., May 20, 1932 (Wm. W. Baker); 1 male, 2 females, Durango, Colo., May 31, 1899; 1 male, 2 females, Havilah, Calif., May 16, 1930 [J. Wilcox Coll.]; 2 males, 2 females, Florrisant, Colo., June 22, 1908 (Rob.); 2 males, 1 female, Creede, Colo., 8844 ft. alt., Aug. 1914 (S. J. Hunter); 1 male, 1 female, Jefferson Co., Colo., June 26, 1913 (A. K. Fisher); 1 female, Douglas Co., Kans., 900 ft. alt. (F. H. Snow) feeding on winged ant (*Camponotus* sp.); 1 male, Las Cruces, N. M., May (Cockerell); 1 female, Reno, Nev., June 23, 1890 (F. H. Hellman); 4 males, 5 females, near Leander, Wyo., 5000-8000 ft. alt., Aug. (Roy Moodie); 1 female, Yellowstone Nat'l Park, June 24, 1930; 1 female, Kennewick, Wash., May 20, 1921 (A. L. Melander); 1 male, 1 female, Kern Co., Calif. [Hine Coll.]; 2 females, Bridgeport, Mono Co., Calif., June 23, 1929, and Mint Canyon, 6 miles west of Palmdale, Calif., Apr. 20, 1932 (E. P. Van Duzee) [Calif. Acad. Sci.]. This species was named in honor of the collector, Mr. C. H. Martin.

***Stenopogon californioides* new species**

Total length, 19-24 mm. A slender species closely related to *californiae* Walker from which it may be distinguished by the structure of the male genitalia. I am unable to give any characters which may definitely distinguish the females.



FIG. 3. Male Genitalia of *californioides*, side view.

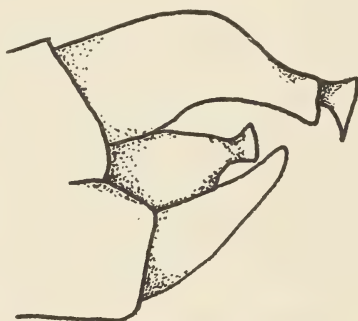


FIG. 4. Male Genitalia of *californiae*, side view.

MALE. Head black, gray-brown pollinose. Antennæ blackish, junction of segments paler. Vestiture of head yellowish. Thorax black with pale brown-



ish-yellow bloom. Vestiture yellowish, hairs along mid-dorsal area of mesonotum black. Legs reddish-yellow, femora with black area in upper and inner portion of first four femora. Hind femora blackish on basal  $\frac{3}{4}$ ths. Wings pale brown subhyaline, basal portion, particularly anal angles, milky-white. Abdomen slender, reddish above; sides and parts of first two tergites blackish. Genitalia blackish, apical prongs of hypandrium about  $\frac{1}{2}$  length of base.

FEMALE. Similar. Tips of hind tibiæ blackish; wings gray subhyaline. Tip of abdomen black. An occasional black hair in upper portion of mystax.

Holotype, male, Lockwood, Calif., July 24, 1935 (E. I. Beamer). Allotopotype, female, same data (Jean Russell). Paratopotypes, 7 males, 15 females, same data (E. I. Beamer, Jack Beamer, Jean Russell). Types in S. W. Bromley Coll., J. Wilcox Coll., and Univ. Kans. Coll.

#### ***Stenopogon arizonensis* new species**

Total length, 21–25 mm. A black species, gray pollinose, related to *tenebrosus* Coq., from which it differs in having the hairs of the mesonotum all pale and the wings are gray subhyaline, pale brownish along veins. The 3rd antennal segment is narrowed toward the tip and bears a longitudinal seam on the lower distal portion.

MALE. Antennæ long, black. Face yellow gray pollinose. Vestiture of head all whitish or straw-colored. Thorax black; gray yellow pollinose; humeri red. Vestiture of thorax and legs sordid whitish. Legs largely black, the articulations, tarsi, and a vitta on the upper inner portion of the front femora chestnut brown. Abdomen black, solid gray pollinose; incisures gray-brown (in two of the paratypes the incisures are broadly reddish-brown). Genitalia compact, narrower than the 7th segment, black in the holotype, reddish-brown in some of the paratypes. Wings gray subhyaline.

FEMALE. Similar.

Holotype, male, Albuquerque, N. M., June 27, 1931, 5000 ft. alt., (Don Prentiss). Allotopotype, female, same data (H. A. Scullen). Paratypes: male, Phoenix, Ariz., Aug. (D. K. Duncan); male, Tempe, Ariz., July (D. K. Duncan); female, Belan, N. M., Aug. 19, 1927 (L. D. Anderson) [J. Wilcox Coll.].

#### ***Stenopogon ebyi* new species**

Total length, 15–16 mm. A small, pale reddish-yellow species, related to *consanguineus* Loew from which it may be distinguished by the smaller size, the more slender build, the entirely pale reddish legs with no black vitta on the hind femora, the black bristles of the hind femora and tibiæ (all reddish in *consanguineus*) and the black bristles of vertex.

FEMALE. Vestiture of head pale straw-colored except the bristles of vertex, which are black, and the antennal bristles, which are dark brown. Thorax

pale chamois-yellow pollinose; all hairs and bristles whitish. Viewed from above the mesonotum with a divided median brown line on the anterior portion, curved back immediately above each humerus. An indistinct brown line on each side of this median line. Scutellum with whitish marginal bristles. Legs pale reddish with mostly black bristles on hind legs; some white bristles in addition to black on first two pairs of legs. Halteres pale reddish-brown. Wings grayish-brown, the veins towards base and their margins somewhat yellowish-red. Abdomen pale reddish-yellow, sides of segments 6 and 7, blackish.

Holotype, female, Cameron Co., Tex., June 30, 1933. Allotopotype, female, same data. Paratopotype, ♀, same data. (All collected by S. W. Bromley and Wayne Eby, in whose honor the species is named.) [S. W. Bromley Coll.] Paratypes, two females, Brownsville, Texas, April 12–May 20 (Dury) [Hine Coll.].

***Stenopogon dispar* new species**

Total length, 19–20 mm. A rather small, slender species of the *Scleropogon* group with the “hypopleura” hairy, the first posterior cell closed and petiolate, the abdomen of the male entirely dull black, that of the female largely reddish above. The antennal style is bristle-like. The dorsum of the abdomen is not pollinose, but the thorax has a distinctly gray bloom. The legs are largely black with the upper inner aspect of the fore femora largely reddish-yellow.

MALE. Antennæ dark brown. Head with gray bloom. Mystax, palpal hairs and beard sordid whitish. Occiput and vertex with blackish-brown hairs and bristles. Thorax black with gray bloom. Humeri reddish. Mesonotum with black hairs and bristles. Scutellum with six stout black marginal bristles. Pleura partly reddish in ground color. Coxæ with sordid whitish bristles and hairs. Legs black, the bases of tibiæ, under sides of femora and bases of tarsal segments faintly reddish-yellow, very obscure in case of femora. The inner upper portion of fore femora and inner aspect of fore tibiæ reddish. Wings gray subhyaline, the anal angle milky whitish, the first posterior cell closed and petiolate. Abdomen dull black with fine scattered black hairs above and sides with a grayish-white bloom. Genitalia black with black hairs.

FEMALE. Similar, but with hairs and bristles of occiput pale yellowish and with the dorsum of the abdomen reddish. The wings are uniformly gray subhyaline, and the posterior portion of the mesonotum bears some white bristles while those of the scutellum are whitish.

Holotype, male, Patagonia, Ariz., Aug. 21, 1935 (E. I. Beamer). Allotopotype, female, same data (R. H. Beamer) [Kans. Univ. Coll.].

**Stenopogon kelloggi** Wilcox new species

“MALE. Length 13 mm. Head black in ground color, densely pollinose, the pollen on the occiput grayish; palpi and proboscis shining black, hairs and bristles yellowish white. First antennal joint yellowish red,  $1\frac{1}{2}$  times as long as second; second joint brown; first two joints with short yellow hairs; third joint and style black, third joint  $1\frac{1}{4}$  times as long as first two joints together; style two-jointed, slender, one-third as long as third joint, with a minute bristle at tip. Thorax brown in ground color; humeri reddish; densely pollinose, as are coxæ; bristles yellowish-white; hypopleura bearing short bristle-like hairs. Abdomen yellowish red in ground color, except sides of first and second segments and narrowly sides of remaining segments which are black; densely pollinose; hairs and bristles yellowish white. Genitalia shining yellowish red, hypandrium emarginate at apex, the two lobes slightly divergent and slightly longer than broad. Legs entirely shining yellowish-red except for a narrow black marginal line on trochanters; claws black, narrowly yellowish at base. Halteres entirely yellowish red. Wings pale yellowish; veins yellowish red but becoming brown apically; costal fringe of spinelike hairs black beyond humeral cross vein; first and fourth posterior cells closed and petiolate, petioles about twice as long as anterior cross vein; anterior cross vein at one-third the length of the discal cell.

“FEMALE. Length 13 mm. Similar to male. Pollen of head and thorax more gray than yellowish. Apical part of sixth and remaining segments of abdomen shining yellowish red, apical spines reddish.

“*Types*. Holotype male and allotype female; Silver City, N. M., IX-16, '32 (R. T. Kellogg); in Wilcox collection.

“*Paratypes*: 47 specimens, both sexes, from type locality, X-25 and 26, '35 (R. T. Kellogg) and from Grant County, N. M., IX-24, '33 (R. T. Kellogg); and base of Pinal Mts., Gila County, Ariz., October (D. K. Duncan).

“This species is close to *coyote* Bromley, but is quite distinct from that species, in which the abdomen and legs are largely black in ground color, the first posterior cell but barely closed at the wing margin, the petiole of the fourth posterior cell shorter than the anterior cross-vein, and the fourth posterior cell large, two-thirds the length of the discal cell, while in *kelloggi* it is but half the length of the discal cell. *S. kelloggi* is smaller and is taken 2 or 3 months later in the season. The hypandria of the two species are similar.”

**Stenopogon duncani** new species

Total length, 17-22 mm. An elongate slender species with pale yellow pollen on thorax and abdomen gray pollinose. The genitalia reddish-yellow.

MALE. Antennæ black. Face yellow-gray pollinose. Vestiture of head straw-colored. Thorax black, humeri reddish. Vestiture of thorax, coxæ and legs pale straw-colored; mesonotum with sordid yellow pollen; pleura with gray-yellow pollen. Wings hyaline with a very faint brown tint. Legs reddish-brown, the first two pairs of femora with a large black vitta above, the posterior black and the posterior tibia, except extreme base, black. Abdomen black, elongate, slender, thickly gray pollinose, ground color of incisures reddish-brown under the pollen. Genitalia compact, reddish.

FEMALE. Similar, except hind femora largely reddish below.

Holotype, male, Silver City, N. M., June 24, 1933 (R. T. Kellogg). Allotopotype, female, Silver City, N. M., June 18, 1933 (R. T. Kellogg). Paratopotype, 2 males, Silver City, N. M., June 24, 1933 (R. T. Kellogg). Paratypes: 1 female, Chiricahua Mts., Ariz., June (D. K. Duncan) (No. 30); 1 male, Beck Hall, Cambray, N. M., June, 1931; 1 female, Ajo, Ariz., Aug. 26, 1927 (J. C. Bradley); 1 female, Florence, Ariz., June 24, 1932 (D. K. Duncan); 1 female, Tempe, Ariz. (D. K. Duncan); 1 male, 1 female, Ariz., C.U. Lot 35 [J. Wilcox Coll.]; 1 female, Clark Val., Colo. Desert, Calif., May 2, 1932 (H. G.) [Calif. Acad. Sci. Coll.].

This species was named in honor of Mr. D. K. Duncan, of Globe, Arizona, who is an active collector of Asilids.

#### ***Stenopogon indistinctus* new species**

Total length, 19–26 mm. A grayish-yellow pollinose species with the first posterior cell closed at the margin or slightly open, related to both *helvolus* Loew and *coyote* Bromley. From the former it may be distinguished by the ground color of the abdomen being more largely blackish and from *coyote* by the larger size, proportionally longer and more slender abdomen, and the color of the posterior aspect of the middle femora which in *indistinctus* are largely reddish-yellow while in *coyote* the black of the upper portion extends at least half-way down on the posterior aspect.

MALE. Head gray pollinose, vestiture straw-colored, becoming darker on occiput and pale orange-brown on vertex. Antennæ black with basal joint largely reddish. Thorax gray-yellow pollinose. The median dorsal marking of the mesonotum blackish and divided longitudinally by a pale line. Vestiture of thorax including scutellum straw-colored. Wings short, hyaline, the first posterior cell closed slightly before or at the margin. Legs reddish-yellow with yellow hairs and bristles, the dorsal aspect of the femora and tibiae blackish. Abdomen elongate, less robust than in *coyote*, with considerable black in the ground color, with a grayish-yellow bloom and slightly lighter colored fine hairs. Genitalia reddish with straw-colored hairs.

FEMALE. Similar, the first posterior cell more inclined to be open than in male. Ground color of abdomen, black and reddish.



Holotype, male, White Mts., Ariz., Aug. 1930 (D. K. Duncan). Allotopotype, female, same data. Paratopotypes, 2 males, 8 females, same data. [J. Wilcox Coll.]. Paratypes: 1 male, 4 females, Concho, Ariz., Aug. 18, 1934 (A. E. Pritchard); 1 male, 2 females, Kenton, Okla., June 27, 1933 (A. E. Pritchard) [A. E. Pritchard Coll.].

***Stenopogon bradleyi* new species**

Total length, 26–29 mm. Related to *neglectus* Bromley from which it may be distinguished by the dull reddish abdomen.

MALE. Face grayish-white pollinose. Vestiture of head pale straw-colored except hairs of vertex which are dark brown. Thorax black except humeri and posterior calli which are deep reddish. Hairs and bristles of thorax, coxæ, and legs pale straw-colored, except fine hairs on mesonotum which are black, and several stout bristles on humeri, dark brown. The thorax is gray pollinose above; yellowish gray pollinose on sides. Scutellum largely dull reddish, covered with gray-yellow pollen. Legs reddish-brown, the femora with a large black vitta, one on the anterior femora on the upper caudal aspect, one on the middle femora on the forward upper side, one on the posterior femora covering largely the anterior and dorsal portions. Wings pale brown subhyaline. Abdomen dull reddish with fine short straw-colored hairs and grayish-yellow sparse pollen, thicker along sides. Genitalia reddish.

FEMALE. Similar, but the bristles on the humeri are sordid yellow instead of dark brown.

Holotype, male, Grant Forest, Calif. (6400–7000 ft. alt.) Aug. 9–13, 1927 (J. C. Bradley Coll.). Allotopotype, female, on same pin. (Evidently taken in coitu.)

This species was named in honor of the collector, Professor J. C. Bradley, of Cornell University.

## BOOK NOTICE

*Über entomologische Sammlungen.* von Walther Horn und Ilse Kahle unter Mitarbeit von R. Korschevsky. Teil I, Seite 1-160, Tafel I-XVI, Dec. 1935; Teil II, Seite 161-296, Tafel XVII-XXVI, Oct. 1936; Teil III, Seite 297-536, Tafel XXVII-XXXVIII, Aug. 1937. Berlin-Dahlem.

The last part of this voluminous and exhaustive work, which appeared in August, 1937, brings to completion a study that was started by Dr. Horn twenty-seven years ago. Like many studies, it grew much larger than the authors anticipated. However, the entomological world should be grateful to Dr. Horn and his colleagues for their industry and perseverance, for we now have an annotated directory, as complete as it could be made, of the entomological collections and collectors, their scope, large and small, over the world. The information, which is both historical and current, is accompanied by 38 plates carrying the handwritten labels of hundreds of collectors and describers. The work should be especially valuable in locating old collections and in determining the identity of labels placed on specimens. And it is a faithful record of the activities of bygone collectors.

In the last volume, Dr. Horn has written various historical chapters dealing with the early entomological history of Central Europe, insect outbreaks, early handling of insects, first private collections, numerous entomologists, first entomological societies and publications, collections in foreign lands, scientific publications, entomological museums, history of the five greatest in Europe, beginnings of entomological museums, especially in Germany, the relation of systematic entomology to general experimental zoology, especially in Germany, the reorganization and reform of zoological museums, and with his thoughts during his forty-eight years of contacts with the museums of many lands.

This brief and inadequate notice does no more than call attention to the wealth of material in Dr. Horn's writings. Dr. Horn has many friends and admirers in the United States, and this, his most recent contribution to entomology, is assured of respect and appreciation.—H. B. W.

SOME NOTES ON COLIAS AND BRENTHIS  
(LEPIDOPTERA, PIERIDÆ AND  
NYMPHALIDÆ)

BY ALEXANDER B. KLOTS  
COLLEGE OF THE CITY OF NEW YORK

This paper consists largely of the record of a collecting trip made during the summer of 1935 by Professor Herbert Ruckes and myself, through New Mexico, Colorado and Wyoming, and especially of notes and observations on the two butterfly genera, *Colias* and *Brenthis*, which I hope some day to monograph. The remainder of the butterfly material from this trip is in the collection of Mr. C. dosPassos.

*Colias* and *Brenthis* present problems of great taxonomic and zoögeographic interest. In common with a considerable number of other butterfly genera they are Arctic in origin, and contain many species common in greater or lesser degree to the Palaearctic and Nearectic.

There is a popular idea that our North American butterflies are very well known scientifically, but this is not so. Far less is known in detail about the butterflies than about many other groups of insects, in spite of (and possibly in part because of) the great popular interest in the group. I therefore take the present opportunity to point out important gaps in our knowledge of various species of these two genera. Probably some of these gaps may be filled by a study of specimens now in various private collections, and in museums which I have not visited; but for others collecting and life-history work will have to be done at strategic locations. Any additional information which may be made available for me will be greatly appreciated.

LOCALITIES VISITED IN 1935

To save repetition the localities in which collecting was done in 1935 are here described at some length. In a number of cases directions for reaching these are included, as these will prove of value to other collectors desirous of visiting these places, some of which are type localities.

LITTLE TESUQUE CANYON, SANGRE DE CRISTO RANGE,  
NEW MEXICO

The locality in which collecting was done lies at 8000-8800 ft. altitude, near the head of Little Tesuque Creek, a few miles north-east of Santa Fe. The region has recently been designated as the Hyde State Park, and an improved road is being constructed up from Santa Fe. It is in middle Canadian Zone, lying in the central part of the coniferous forest belt. In the moist valley the forest of Yellow Pine (*Pinus ponderosa*) gives way largely to firs; but on the steep hillsides, where the run-off of water is great, the pines predominate to considerably higher elevations. The majority of the butterflies are to be found in the small, grassy meadows in the valley, although some, such as *Polygonia* ssp., *Basilarchia wiedmeyer*i, *Pieris napi*, etc., prefer the shaded woods, and others, such as *Hypaurotis chrysalus*, prefer the thickets of Chaparral Oak (*Quercus gambeli*).

ASPEN RANCH, SANGRE DE CRISTO RANGE, NEW MEXICO

Like Little Tesuque Canyon, this locality is on the western side of the mountain range; it is a few miles further north than Little Tesuque Canyon. The environment does not differ essentially from the description above. Around Aspen Ranch many of the mountain sides were burned off, about forty years ago, I believe. The faster-growing Quaking Aspen has repopulated these areas, and is only very slowly being replaced by sparse growths of climax conifers. In June, 1935, the aspen groves were being very severely attacked by the western tent caterpillar, whole hillsides being defoliated, and the spruce bud worm was very plentiful in the conifers, so that the trees were having a hard time.

WINDSOR CANYON, COWLES, NEW MEXICO

Cowles is located nearly at the end of the road that leads north from Pecos along the Pecos River, a mile below the Panchuela Ranger Station; at this latter place we made our base camp. This is on the east side of the main Sangre de Cristo ridge, nearly opposite the localities described above. Windsor Creek flows eastward from Santa Fe Baldy Peak ("Baldy Peak" on the U. S. Topographic map, Santa Fe Quadrangle) and at Cowles joins



the upper waters of the Pecos. Up Windsor Canyon runs a Forest Service trail, with branches to Santa Fe Baldy and Lake Peaks, which leads westward across the range to Santa Fe.

Collecting at Cowles and in Windsor Canyon was done in the grassy, well-watered fields and meadows. The effect of the dry winds from the west is well illustrated by a comparison between this locality and Aspen Ranch on the western side of the range; for at the latter locality the winds, bone-dry from their passage over hundreds of miles of desert, take on moisture, while here they discharge it. As a result Cowles has a much more luxurious true Canadian Zone flora and fauna at a lower elevation than Aspen Ranch at a higher elevation. Cowles is at about 8000 ft. elevation; at Aspen Ranch Transition and lower Canadian Zone elements are found on the dry hillsides even up to 10,000 ft. It is thus seen to be moisture, and not merely temperature, that here largely determines the lower limits of the coniferous forest, although of course these two factors are largely interdependent.

#### SANTA FE BALDY PEAK

Along the trail up from Cowles (see above) one passes through heavy Canadian Zone coniferous and aspen forest, with occasional small, grassy meadows or "parks." Timberline on Santa Fe Baldy occurs quite abruptly at about 11,700 ft., the trees extending on comparatively gently sloping ground nearly to the margin of the small lake that lies within the curve of the cirque of the peak. Around this lake are some nearly level, grassy meadows. From here, steep, grassy or boulder-strewn slopes lead upward for several hundred feet rise in elevation to the long, curved, barren ridge of the peak. A noteworthy series of *Oeneis*, many of them quite worn, was taken on the very top of this ridge by Mr. Richard Whitmer of our party. The species has been determined as *O. brucei* Edw. by Mr. dosPassos. None of these butterflies were seen at all below the very crest of the ridge.

Santa Fe Baldy and Lake Peaks, together with Truchas and Jicarilla Peaks further north, probably represent the southernmost extension of any sizable areas of Hudsonian and Arctic Alpine Zones in the continuous Rocky Mountain chain, and so are worthy of a great deal of careful study and collecting.

## ROCK CREEK, VIC. OF COLORADO SPRINGS, COLORADO

Collecting was done in the grassy meadows near the Fountain Valley School cabin, at about 8400-8800 ft. altitude. This was in the middle of typical, heavy, Canadian Zone coniferous forest, *Pinus ponderosa*, *Abies concolor*, *Picea pungens*, *Pseudotsuga mucronata* and *Populus tremuloides* being the dominant trees. Nevertheless, *Yucca glauca* occurs here, and such tropical butterflies as *Nathalis iole* and *Eurema mexicana* are common and well established.

## HALL VALLEY, COLORADO

For directions for reaching this famous collecting locality, important because of the work of Bruce, Snow, W. H. Edwards and Barnes, I am indebted to Mr. F. M. Brown. Hall Valley is located in the extreme northwest corner of Park County, and may be found on the Montezuma Quadrangle of the U. S. Topographic maps. It can be reached from the "town" of Webster, which is located on U. S. Highway No. 285, about 14 miles west of Bailey.

Hall Valley is a long, narrow valley that extends up from lower Canadian Zone meadows at Webster, and ends in a large area of Hudsonian and Arctic-Alpine Zones. At the upper end is a striking cirque of about 11,500 ft. altitude, which is rimmed by the high ridges of the Continental Divide reaching heights of 12,500-12,952 ft. Timberline occurs in the valley floor at 10,700-11,000 ft., although growths of greatly stunted spruce push somewhat higher on some of the slopes. In the upper end of the valley are large areas of grassy meadows and low willow brush; the steep slopes of the valley sides are covered with short herbage in between areas of rocky slides; and the remnants of an ancient peneplain that form the tops of the encircling ridges are typical, Arctic-Alpine, short-grass tundra. Many bog areas occur in the valley floor, both above and below timberline, and there are frequent beaver ponds in the course of the rapid stream that flows down the valley.

I know of no more attractive locality in the Colorado Rockies than this, combining as it does accessibility with inspiring scenery and excellent high-altitude collecting. It is the type locality for a number of butterflies; and it should be an ideal place for some much-needed ecological and life-history studies.

## PINGREE PARK, COLORADO

Pingree Park is a large, grassy meadow, or "park," located near the peaks of the Mummy Range, west of Fort Collins, Larimer County. It may be found on the Home Quadrangle of the U. S. Topographic maps. It is reached best by automobile road from Fort Collins, *via* Poudre River Canyon. Pingree Park lies at 9000-9500 ft. elevation, in the middle of Canadian Zone forest belt. Here, every August, is held the annual meeting of the Rocky Mountain Entomological Conference. I can well attest that a visit to this meeting will repay a visitor manyfold in knowledge gained from the scientific programs, in acquaintance with some very excellent territory, and in pleasant friendships.

MUMMY PASS, ROCKY MOUNTAIN NATIONAL PARK,  
COLORADO

About 8 miles from Pingree Park, from which it can be reached by trail, Mummy Pass lies at an elevation of 10,500-11,400 ft., in the extreme northern part of the Rocky Mountain National Park. Ascending from Pingree Park, the forest belt ends rather abruptly with a scattering of *Picea*, *Abies* and *Pinus flexilis*, so that Hudsonian Zone is rather limited. There is a very large area of grassy, Arctic-Alpine tundra, with occasional willow bogs. On the peaks (Comanche Peak, Mummy Mt., Hagues Peak and Hallett Glacier) on either side of the pass are steep, rocky slopes where vegetation often maintains a precarious foothold, and where Pikas and Ptarmigan abound. It is a long, stiff trip up from Pingree Park and back on foot, but an entomologist will be repaid by some excellent high-altitude collecting in season.

## SNOWY RANGE, WYOMING

During the week of July 17-23 we stayed at the University of Wyoming Summer Camp, where excellent geological and biological laboratories are being completed. This is ideally located near the upper limit of the coniferous forest, in the Snowy Range at the northern end of the Medicine Bow Range. An excellent motor road is now being constructed westward from Laramie across the Laramie Plains to Centennial; hence it crosses the Snowy Range, passing through many miles of very beautiful Hudsonian Zone,

drops down on the west side of the range, and connects with the road to Saratoga and the Lincoln Highway at Walcott. There are now few more accessible localities in the Rocky Mountains than this, where high altitude collecting may be done at the running board of one's car, so to speak; and any entomologist who visits the Snowy Range will be well repaid for his efforts.

The season was very late here in 1935, as elsewhere also, so that during July many species were found just beginning to emerge that normally would have been flying in quantities. A return visit to the Snowy Range was paid on August 13, and much interesting data secured regarding the seasonal succession of many species.

The Snowy Range may be located on the Medicine Bow Quadrangle of the U. S. Topographic map.

#### MIDDLE PINEY LAKE, WYOMING RANGE, WYOMING

Reached by a rather poor road westward from Big Piney, Sublette County, Middle Piney Lake lies at 8818 ft. altitude, in about middle Canadian Zone. The grassy meadows and mountainsides around the lake offer interesting collecting; while Wyoming Peak and its surrounding buttresses, rising to considerable areas of Arctic-Alpine Zone, present some very interesting zonal distribution problems. Near the foot of the lake a very large area of slide rock has come down from the mountain to the southeast, and forms thus a continuous connection between the middle Canadian Zone meadows of the lakeshore and the Hudsonian areas on top of the mountain. A number of species that are normally found only in the rock slides above timberline have here spread downward, offering a very interesting example of intrusion. The Pika (*Ochotona*) is thus found in this rock slide surrounded at a short distance by typical middle Canadian Zone flora and fauna; and a specimen of the normally Arctic-Alpine Copper butterfly, *Lycaena snowi* Edw., was taken on a rock pile near the lakeshore. Such cases lead one to suspect that it is the immediate environment, rather than any larger "Life Zone" influence, that largely determines the distribution of such organisms. Both the species mentioned above may be termed "petrophiles," for they are seldom if ever found away from the imme-



diates neighborhood of large masses of broken rocks; and probably they will, within reasonable limits, be found wherever this type of environment occurs, regardless of minor Life Zone differences.

This does not, however, invalidate the entire Life Zone theory, as some ecologists would insist. There must be thousands of square miles of slide-rock territory in the Rocky Mountains that should be perfectly suitable for such petrophilous species as Pikas, *Lycaena snowi*, *Erebia magdalena*, etc., yet which, lying in lower Canadian or Transition Zone, will never be occupied by them. In such cases the change would be too great. These species are sufficiently adaptable to make successfully the change from Hudsonian to upper or middle Canadian Zone, and even when circumstances allow, I do not doubt, to lower Canadian. But beyond a certain limit they cannot extend. Temperature is without a doubt, a large factor in this; but there must be others. And it is the sum of all these factors that determines the ecological category which we term the "life zone." Like most sweeping ideas the Life Zone Theory has suffered as much at the hands of overenthusiastic friends as from opponents; but this is no reason for throwing it away *in toto* and descending into a welter of minor, unclassified "associations" as some ecologists would.

Wyoming Peak and Middle Piney Lake are to be found on the Afton Quadrangle of the U. S. Topographic maps.

The Wyoming and Salt River Ranges are of especial interest to the taxonomist and zoögeographer. They probably represent the southernmost limit of distribution of many northern species and subspecies which, having spread southward through the Yellowstone Park, Teton, Snake River and Hoback Ranges, are here prevented from further extension of their ranges by lack of suitable mountain connection. A road up Greys River, which lies between the Wyoming and Salt River Ranges is, I believe, in process of at least partial construction by the C. C. C.; if it does not result in bringing in a swarm of firebug tourists, this should be of great value to scientific collectors.

#### GREEN RIVER LAKE, WIND RIVER RANGE, WYOMING

Green River Lake, located about 50 miles north of Pinedale, is at the head of the Green River; it may be located on the Fremont

Peak Quadrangle of the U. S. Topographic maps. The lake lies at an elevation of 7958 ft. and is nearly at the bottom edge of the coniferous forest. Transition Zone sagebrush and *Potentilla* "flats," and grassy meadows extend up the valley bottom to the lake; and a heavy Lodgepole Pine (*P. murrayana*), Spruce and Fir forest covers the Canadian Zone mountain slopes, extending down to the shores of the lake. Trails lead from the lake up neighboring mountains, as well as into the heart of the as yet unspoiled Wind River Range. We climbed Little Sheep Mountain (alt. 10,175 ft.) on the west side of the valley, and Mt. Osborne (11,905 ft.) on the east side. Little Sheep Mountain barely reaches to timberline, but excellent collecting is to be found in the grassy meadows and parks traversed during its ascent. On Mt. Osborne the timberline occurs at about 10,500 ft. Just below timberline the spruce-Douglas fir forest gives way abruptly to a narrow, upper belt of White-barked Pine (*Pinus albicaulis*). Above this is a large area of grassy and rocky Arctic-Alpine tundra, where excellent collecting may be had. At the date we reached this no *Oenis* were flying (Aug. 5), but an excellent series of *Erebia callias* Edw. was taken, the species being sharply limited to upper Hudsonian and Arctic-Alpine Zones. *Erebia sophia ethela* Edw. was common also, but limited to Canadian Zone meadows.

To many friends, both old and new, Dr. Ruckes and I are indebted for help and advice on this trip. In particular I wish to express my appreciation of the splendid work being done by the Rangers of the U. S. Forest Service, in preserving as best they can the forests of our West, and at the same time in opening up new trails and in keeping old ones passable. Of course, too much can be done in the matter of encouraging the general public to penetrate these forest areas; the fire hazard is enormous at all times, and a careless tourist can do almost irreparable damage with one match. In some parts of the west, recent, politics-inspired, "public works" programs are in this way opening up large forest areas to the public without making adequate provision for their protection. But among the men of the Forest Service I have never failed to find a desire for true conservation,

based on knowledge gained in the field and not in a desk-chair; and the interest of these men in scientific work, and their unfailing courtesy and helpfulness, are things that I shall always remember with deep pleasure and appreciation.

### *Colias meadi* Edwards

Large series of *C. m. meadi* were taken in the Snowy Range, July 17-23 and August 13, and at Mummy Pass, August 18 and 20, where this fast-flying species abounds in Hudsonian Zone tundra, and is somewhat less abundant in Arctic-Alpine Zone. All the July specimens were freshly emerged; in both localities collected in August the majority of the specimens taken were still very fresh, although some were rather worn.

According to my experience *m. meadi* is largely limited to the shadeless, grassy meadows at and above timberline; of many hundreds of specimens which I have taken, and of more hundreds which I have seen, but few have been in meadows of the Canadian Zone forest belt. Not only does *m. meadi* almost certainly never breed in Canadian Zone, but adults blown down below timberline lose no time in flying back up again. Probably a very strong positive phototropism or "heliotropism" is responsible for this.

Series of specimens referable to *C. meadi elis* Edw. were taken in both the Wind River Range (Little Sheep Mt., July 25-Aug. 7, and Mt. Osborne, Aug. 5) and the Wyoming Range (vic. Middle Piney Lake and Wyoming Peak, Aug. 8-12). The chief characteristics of *elis* as compared with *meadi* are as follows:

(1) greater size; (2) lighter orange ground color above, especially in the males; (3) larger size of the spots in the black marginal borders of the females; (4) less greenish-fuscous suffusion on the under side of the secondaries of the males; (5) a less well-marked discal spot on the under side of the secondaries, due to reduction in width of the purplish-pink area surrounding the spot; (6) a more northern distribution—see below.

It is probable that the Wind River, Wyoming, and Salt River Ranges mark the southern limit of distribution of *elis*, which ranges northward into Alberta and British Columbia, and possibly Alaska. The Snowy Range undoubtedly marks the northeastern limit of *m. meadi*. I have seen no material from the Uintas or other Utah localities, so cannot be sure of the northwestern limit of *m. meadi*, or the southwestern limit of *m. elis*.

More marked than most of the color and pattern differences between *m. meadi* and *m. elis* is the difference in habitat of the two races. *Elis*, though ranging as far up into Arctic-Alpine Zone as *meadi*, is at times to be found common in middle Canadian Zone meadows and parks, entirely surrounded by heavy coniferous forest. At Middle Piney Lake, numerous specimens were seen and many taken, visiting *Helianthus* blossoms in typical Canadian Zone meadows and unforested hillsides; the center of abundance of the species was, however, somewhat higher up, in lower Hudsonian Zone. The same thing was noted in the Wind River Range, and here several specimens were taken even as low as at the edge of the sagebrush plains that cover the valley floor at about 8800 feet altitude. In the course of considerable experience with *m. meadi* I have never seen this, although doubtless specimens of the latter race do occasionally stray down-mountain for considerable distances.

### **Colias eurytheme** Boisd.

Various forms and broods of *eurytheme* were taken everywhere that collecting was done. In its zonal as well as its altitudinal range *eurytheme* is the most widespread of Nearctic *Colias*, occurring commonly in all Life Zones, as well as from Alaska to central Mexico. At present we are really very ignorant of the conditions which presumably influence the appearance of the various color forms, and can, with security, make only rather vague generalizations. Cold weather and high altitude have comparable effects, and in general seem to produce the forms *autumnalis* and *eurytheme*. Warmer conditions bring about an increase in size and in richness of coloration, often producing, or at least being accompanied by, *eriphyle* and sometimes small *amphidusa* specimens. Hot weather is accompanied by large, richly colored *amphidusa*; but in many localities *eriphyle* continues to emerge throughout the summer and flies in company with *amphidusa*; and even specimens referable on the basis of size and color to *autumnalis* may be found flying in such mixed company.

All of the above statements are liable to frequent exception, depending on geographic location, local environment, weather, etc., so that an enormous amount of very carefully controlled



breeding work will have to be done, under experimental conditions of temperature and humidity, before the problem can begin to be understood. I very strongly suspect that some inheritance-factors will be found to enter into the matter; but in any event it cannot be denied that *eurytheme* is extremely sensitive to changes in the physical environment, and presents a very complex and as yet quite unresolved problem.

### *Colias astraea* Edw.

A considerable number of *C. astraea* were seen, and a small series taken, in the valley of Clear Creek just below the "Natural Bridge," near the head of the lower Green River Lake on August 3. The species appears to be extremely limited in its ecological range. All of the specimens seen were in a rather peculiar, grassy-sphagnaceous type of bog, in which small clumps of willow were interspersed. Females were seen dropping into the low herbage as if ovipositing, but no definite evidence of the accomplishment of this act was secured.

The very restricted environment in which the colony was found is of considerable interest in view of the present lack of knowledge of the relationship of *astraea* to *christina* Edw. The latter species is a Lupine feeder, but there was no Lupine in the bog where these *astraea* were taken; moreover, no *astraea* were seen in contiguous territory where Lupine abounds. I strongly suspect that *astraea* and *christina* are really distinct species, and not merely forms of a single species as is usually considered to be the case.

The whole problem of the interrelationship of *christina*, *astraea*, *alexandra*, *gigantea* and *interior*, and the identification of many specimens of these species, is at present a very puzzling one. It will probably never be resolved satisfactorily until a great deal of careful breeding work, like that of Gerould on *philodice*, has been carried out. The more one studies these species by specimens alone the more one is puzzled, for perfect series of intergrades exist between most of them; and so a large percentage of specimens from the Northwest cannot be named with any assurance.

### *Colias alexandra* Edw.

In 1935 *alexandra* was found common in nearly every suitable locality where collecting was done. It is essentially an inhabitant

of the lower half of the Canadian Zone, although specimens frequently occur in upper Transition and Canadian Zones. It thus occupies a definitely lower zonal range than *C. scudderi*. The males show an especial fondness for mud puddles, sometimes congregating in large swarms.

Definite records for 1935 are: Windsor Canyon, Cowles, N. M., July 2, very common; Hall Valley, lower end near Webster, July 15, uncommon; vic. of Estabrook, Colo., July 12, common; Pingree Park, Aug. 18-23, common in middle to lower Canadian Zone, specimens mostly worn, some quite fresh; Foxpark, Albany Co., Wyo., July 20, common in lower Canadian Zone; Green River Lake and vic. July 24-Aug. 7, uncommon, ranging from upper Transition Zone sage flats (rare) up to meadows and "parks" in mid-Canadian Zone at about 9500 ft. alt.

The large series of specimens taken at Cowles averages considerably larger than topotypical Colorado material, but definitely belongs to *a. alexandra* and not to the Great Basin race *edwardsi* Edw. Specimens from Wyoming average a bit smaller than Colorado series, are underneath somewhat more heavily suffused with greenish-fuscous, and have more traces of a pinkish ring around the discal spot of the under side of the secondaries.

Some very thorough collecting and study is needed in order to clear up the relationship of *alexandra* and *christina*. In most parts of their common range these two species are perfectly distinct; but many specimens from Idaho, Washington and southern British Columbia cannot distinctly be named as either *alexandra* (*emilia* Edw.?) or as yellow *christina*. The intergradation of the two species in this region is all the more puzzling when we consider that from east of the Continental Divide in central Montana and northern Wyoming, *alexandra* is small and heavily infuscated beneath—not at all like the *christina* from the same region. It is possible that the two forms are really not distinct in Idaho and northern Utah; but that *alexandra* was able to extend its range southward from there into New Mexico (with an offshoot westward into California), then east around the southern end of the Rockies, and northward in the Colorado mountains to Wyoming and Montana. By the time it reached there it had differentiated greatly and hence diverged from *christina* to a point of unmis-

takable specific identity. *Christina* undoubtedly does not extend very far southward in the Great Basin region; I have specimens from Payson, Utah, but none south of that point.

### *Colias scudderi* Reakirt

*C. scudderi scudderi* was taken as follows: Hall Valley, July 14, 1 fresh ♂ in upper Canadian Zone meadow; Mummy Pass, July 19, 1 ♂, 1 ♀ quite fresh specimens, in Arctic-Alpine Zone, the male flying over tundra, the female in a willow bog; Pingree Park, several males, August 18-22, all badly worn; Snowy Range, July 17-23, and Aug. 13, common.

In the Snowy Range in July the species was rather common in small, grassy meadows and glades somewhat below the upper edge of the coniferous forest belt, and was only rarely present in the larger, more open, tundra and meadows in Hudsonian Zone. The majority of specimens taken at this time were fresh and recently emerged, but a few were quite worn, and had evidently been flying for a week or two. In the same locality on August 13, however, the center of distribution had moved upward, so that the species was common in the higher Hudsonian and Arctic Alpine tundra and meadows. Of 8 females taken at this locality in both July and August, 3 are light yellow, and 5 are white.

*Scudderi* is definitely a butterfly of the Upper Canadian and Hudsonian Zones, although during the first part of the season many specimens will be found in middle Canadian Zone. It thus contrasts strongly with *alexandra* which is practically always found in the same general localities but which is essentially of the lower and middle Canadian Zone.

I have no records of *scudderi* from north of the Snowy Range in Wyoming, west of the Uinta Mts. in Utah, or south of the Sangre de Cristo Range in northern New Mexico. Further collecting is desirable, to determine whether it occurs in any other parts of the West. *Scudderi* has always been considered as limited to Colorado, so that its presence in the Uintas is rather surprising, and holds forth the possibility that it may occur in the Wasatch Range and even reach southeastern Idaho; I strongly doubt this latter, however. The arid country of the Red Desert and southwestern Wyoming seems to be a dividing line between

northern and Colorado forms in a great many cases, and will probably prove so in this one.

***Colias scudderi ruckesi*, new geographic subspecies**

A large series of *C. scudderi* taken in Windsor Canyon in both 1935 and 1936 shows sufficient differences from *C. s. scudderi* to warrant the description of a new geographic subspecies based on this material. I name this *ruckesi* in honor of my companion in 1935, Dr. Herbert Ruckes. From *s. scudderi*, *ruckesi* differs chiefly in the following characteristics:

(1) In *ruckesi* the black marginal border of the upper side of the wings of males is proportionately wider than in *s. scudderi*.

*ruckesi*, 45 ♂ ♂

Average length of fore wing .....	22.68 mm.
Average width of border in cell $M_1$ of fore wing ...	5.786 mm.
Border-width percentage of wing-length .....	25.51%

*scudderi*, 52 ♂ ♂

Average length of fore wing .....	22.860 mm.
Average width of border in cell $M_1$ of fore wing ...	4.984 mm.
Border-width percentage of wing-length .....	21.80%

(2) In *ruckesi* the black discocellular spot of the upper side of the fore wings of males is more often reduced in size, or absent, than in *s. scudderi*.

*ruckesi*, 45 ♂ ♂

Spot present, large .....	2 = 4.44%
Spot present, small .....	11 = 24.44%
Spot present as a trace .....	10 = 22.22%
Spot absent .....	22 = 48.88%

*scudderi*, 52 ♂ ♂

Spot present, large .....	9 = 17.3%
Spot present, small .....	16 = 30.7%
Spot present as a trace .....	20 = 38.4%
Spot absent .....	7 = 13.4%

(3) The ground color of fresh specimens of *ruckesi* is a brighter, more intense yellow than that of *s. scudderi*.

(4) The black basal dusting on the upper side of the wings is somewhat heavier and more wide spread in *ruckesi* than in *s. scudderi*.

Holotype male, allotype female, nineteen male and one female paratypes, from Windsor Creek Canyon, west of Cowles, N. Mex., July 2, 1935, collected by the author. Twenty-five male and nine



female paratypes from the same locality, July 4, 1936, collected by L. E. Chadwick, Richard Whitmer and the author. All were taken in about middle Canadian Zone, at from 9000 to 9500 ft. altitude, in grassy meadows surrounded by forest, along the Forest Service trail about halfway between Cowles and the summit of Santa Fe Baldy Peak.

Holotype, allotype, six male and two female paratypes deposited in the American Museum of Natural History; four male paratypes deposited in the U. S. National Museum; four male paratypes deposited in the Canadian National collection; the remainder of the paratypes at present in the author's collection.

Although *ruckesi* is not an extremely well-marked race, I am convinced that it is worth naming. It is not to be expected that in such a race as this every specimen will be distinct from any specimen of another race; and such is the case here. In the type series of *ruckesi* are at least eight specimens which from appearance might well be *scudderi*; and I have one specimen of *s. scudderi* from Twin Lakes, Lake Co., Colo., that in appearance is a perfectly typical *ruckesi*. A series of *ruckesi* has, however, a very distinctive appearance, and is separable at a glance from a series of *s. scudderi*. In fact, with its wide, dark borders and its reduced discocellular spots, such a series is at first glance very strikingly suggestive of *C. palaeno*.

The race *ruckesi* may be taken as representing the southern part of the population of *scudderi*. I doubt that *scudderi* will be found to occur south of the Sangre de Cristo range; but if it should be taken in the Mogollon, Sierra Blanco-Sacramento or Sandia-Manzano Ranges, the more southern specimens may well prove even more different from *s. scudderi* than the type series described above.

Only eleven females were taken, a number insufficient to warrant any generalizations regarding the characteristics of this sex of *ruckesi*. Of these 5 are bright yellow, 2 are yellowish-white, and 4 are white. Of 37 females of *s. scudderi* from Colorado, Utah (Uinta Mts.) and southern Wyoming which I have studied, only 7 are definitely yellow; so this color in a larger proportion of the females may be a characteristic of *ruckesi*.

One of the females taken in 1936, when confined in a jar with samples of most of the potential food-plants of the region, laid

several eggs on willow and ignored everything else. Unfortunately the larvæ emerged in Arizona, and all succumbed to the heat of the desert, which was very understandable at the time.

### *Colias pelidne skinneri* Barnes

Two males and a white female of this interesting form were taken at Middle Piney Lake on Aug. 10 and 11, flying along a steep, unforested hillside; one male and the female were visiting a species of *Polygonum*, and the other male was on a large, orange *Helianthus* in company with other butterflies.

It is probable that the Wyoming and Salt River Ranges mark the southern limit of distribution of *pelidne*, although there is a possibility that it may occur in the Wasatch or Uinta Mts. It almost certainly does not occur in the Colorado and contiguous ranges.

### *Brenthis aphirape* Huebner

A series of *B. aphirape alticola* B. & McD. was taken at the type locality for this subspecies, Hall Valley, on July 15. Almost all were flying in a grass-sphagnum bog at about 11,000 ft. alt., near the upper limit of timber but in upper Canadian Zone. Only one specimen was taken outside of the limits of the bog, and that one was visiting flowers on a contiguous slope. Previous collecting in other parts of the valley had failed to reveal any specimens, but the reason for this was made evident when the rather restricted habitat of the species was discovered. All the specimens were freshly emerged.

One just-emerging, crippled male was taken in a Hudsonian Zone, grass-willow bog between Glass Lake (now, in 1936, known as Lewis Lake) and the base of Medicine Bow Peak, in the Snowy Range, Wyo., on July 22, and three more specimens were taken in the same place on August 13; of these latter three, two females were quite fresh and the third, a male, was rather worn. Intensive collecting in neighboring meadows and tundra, carpeted with flowers and swarming with *Brenthis helena*, failed to reveal any more specimens; so that it seems as if here, too, *aphirape* is restricted to a bog environment.

The considerable series of topotypical *alticola* from Hall Valley as well as a number of other specimens from other Colorado

localities which I owe to the kindness of Messrs. F. M. Brown and L. E. Chadwick, enable me to here characterize *alticola* somewhat more fully than was done in the original description, especially with regard to *B. a. dawsoni* B. & McD., geographically the nearest of the other *aphirape* subspecies.

*Upper side.* The ground color is a lighter, more yellowish brown, the black transverse markings are narrower and more clean-cut, and the black basal dusting is less evident; there is less evidence of the presence of a hazy, zigzag, fuscous line basad of the submarginal row of round, black spots on the primaries, and distad of the outermost, zigzag, black line.

*Under side.* The ground color is a slightly lighter tan, but not appreciably different from that of *a. dawsoni* and *a. tricularis*.

*Under side of secondaries.* The dark bands (postbasal, median and submarginal) are a much lighter, orange-brown than in *dawsoni*, in which these bands, especially the postbasal and median, are darker, ranging from a dark orange-brown to a very dark reddish-brown. The submarginal dark band (immediately basad of the marginal row of triangular spots) is invariably interrupted sharply in cells  $M_2$  and  $M_3$ , while in *dawsoni* and *tricularis* this band is often complete. The median dark band is clear-cut, while in *dawsoni* and *tricularis* its edges, especially the outer edge, are very diffuse. The postbasal dark band is much narrower than in *dawsoni* and *tricularis*; this is especially noticeable in the spot of this band located in the discal cell, which is invariably narrower than the light spot immediately basad of it; in *dawsoni* and *tricularis* the band-spot in the cell is usually wider than the basal light spot.

The above-mentioned spot in the cell of the dark basal band may contain a light spot, but in *alticola* this is usually not the case. Of 18 specimens of *alticola* this spot is present, large and ocellate in 1, is present as a mere whitish trace in 3, and is absent in 14; of 64 specimens of *dawsoni* and *tricularis* the spot is large in 43, is present as a trace in 17, and is absent in 4.

The light, basal and submedian bands of spots are of a clear yellowish color, with a faint trace of silver in only 2 out of 18 specimens. In all 18 specimens of *alticola* the spots of the marginal row are slightly iridescent silvery, except in two in which they are strongly silvery. In *dawsoni* and *tricularis* the silvery iridescence is strongly marked in the majority of specimens in all the spots of the three bands.

In most of the above characteristics *alticola* is much more different from Manitoba (including Churchill), Alberta and Saskatchewan *dawsoni* than it is from truly Arctic specimens (mostly good *tricularis*) from Alaska and Labrador; in fact, a number of specimens from these latter regions are very close to *alticola*, and would excite no comment if taken in Colorado.

A resemblance of this kind led Leussler (Bull. Brooklyn Ent. Soc. 1935, 30: 52) to record *alticola* from the Mackenzie delta at the same time that he referred to other Arctic specimens as *dawsoni*. Such a procedure is based on an erroneous concept of the principles of subspecific taxonomy. The name "*alticola*" does not apply to *any* specimen with the *alticola* characteristics, no matter where found; it should be used solely to refer to the *population* of specimens of the species *aphirape* that occupy that *area* where *alticola* characteristics are predominant, even though occasional specimens from that area may not (phenotypically at least) possess these characteristics. Individuals from a thousand or two miles away from Colorado are a part of a population from a different area, and therefore, in this case, a part of a different subspecies. A most interesting case of this kind is described below under *B. h. helena*.

As noted above only four specimens of *aphirape* were taken in the Snowy Range, and this hardly constitutes a sufficiently large series on which to base any conclusions. It is worth recording, however, that all of these specimens are in color and pattern much closer to *dawsoni* than to *alticola*, which is far from what one would expect. Study of the distribution of *Colias* and *Brenthis* in the Rocky Mountain region shows that in the majority of cases the "break" between a Canadian race and a southern mountain race seems to come either in Montana or at the great ecological barrier of the Red Desert in Wyoming and the Great Basin lowland country in northern Utah. There is no apparent topographical, climatic, or other environmental barrier between the Snowy Range and the mountains of central Colorado where typical *alticola* occurs; so that the occurrence of *dawsoni* in the Snowy Range and of *alticola* in the contiguous ranges southward would be most surprising. Very probably more complete collecting will solve the problem.

#### *Brenthis myrina tollandensis* B. & McD.

One specimen only, a freshly emerged female, was taken; this was in a grassy marsh about three-quarters of a mile below the University of Wyoming camp, in the Snowy Range, on July 20. This agrees with the writer's previous experiences with this spe-



cies in the Rocky Mountains; it is rather rare and of very local distribution, occurring only in marshy places. It seems to emerge later in the season than the other, more typically Western species of *Brenthis*.

#### *Brenthis kriemhild* Strecker

Only one specimen of *B. kriemhild* was taken in 1935, a very badly worn female; it was in a lower Canadian Zone meadow at Green River Lake, August 5. In my experience *kriemhild* emerges somewhat earlier in the season than other species of *Brenthis* found in the same localities. It appears to be typically a lower to middle Canadian Zone species.

Records from eastern Utah and western Colorado are needed to fix the southeastern limits of the range of this species. At Payson, Utah, it is common, but I know of no more eastern records than this; it is very possible, however, that it occurs on the western slope in Colorado.

#### *Brenthis helena* Edwards

*B. helena* Edw. was taken at all suitable localities where collecting was done.

At Cowles, N. M., on July 2 two very fresh males were taken in a small meadow in Windsor Canyon, at about the upper middle of the Canadian Zone forest belt; this constitutes the southernmost record for the occurrence of this species of which I am aware. It also represents the lowest life-zone record I have for *helena helena*, which may be due to the fact that it was very early in the season and that the species was just beginning to emerge. One additional *Brenthis*, doubtless a *helena*, was seen on the same day in Hudsonian Zone on Santa Fe Baldy Peak at about 12,000 ft. alt. These New Mexico specimens do not appear to differ in any important respect from Colorado specimens, except that they seem brighter red beneath.

The species was found common at Hall Valley on July 15; this was in swamp and swampy meadow in upper Canadian and lower Hudsonian zones, at about 11,000 ft. alt. Many were flying and visiting flowers in company with *B. aphirape alticola*.

A considerable series of freshly emerged males, but no females, was taken in the Snowy Range from July 15 to July 23, and rep-

resented the earliest emergents of the species for the season in this locality. All were in Hudsonian Zone grassy meadows above the upper limit of the forest. On August 13 the locality was revisited, and a large series was taken, the species being found in abundance in the same environment. A number of specimens were also taken higher up on the slope of the mountains in upper Hudsonian Zone; but even at this late date no specimens at all were seen in Canadian Zone meadows, although a few hundred feet up the mountains the species was common. It is interesting to note that whereas in July only males were taken, in August the sexes were present in nearly equal numbers.

A series of *helena* was taken at Mummy Pass on August 19 and 21; all were found in Hudsonian and Arctic-Alpine zone meadows and tundra only.

A number of the specimens collected in the Snowy Range are rather peculiar and extremely interesting, for they show distinct resemblance to *B. chariclea chariclea* and *B. chariclea arctica*. On the underside of the secondaries the marginal row of spots, and the spots of the submedian light band immediately above, at the end of and below the discal cell are silvered; the remainder of the spots of the submedian band tend to be obliterated by the ground color; the spot at the end of the cell is greatly elongated and pointed; and the ground color is a rich, reddish brown with purplish shades. One of the specimens is so nearly perfect a match for a specimen of *chariclea arctica* from White Strait, Baffin Land, that either might well be mistaken for the other if the data labels were ignored.

I have long considered that *chariclea* is the closest relative of *helena* and probably represents somewhat of an ancestral form. This being so, the circumpolar *c. chariclea* and *c. arctica* might well be expected to show greater resemblance to *helena* than the more southern *c. grandis* or *c. boisduvalii*. At the close of the last glaciation, *chariclea* probably spread rapidly southward in North America, with the result that for a time all of the suitable parts of the continent would be occupied by a comparatively homogeneous population. Then as time went on, and the climate became milder, barriers would arise and isolation factors come into play; the homogeneous population would be split into a num-

ber of more or less separated populations, although these need not be actually different from each other; and opportunity for subspeciation and speciation would come. The final result, the production of such variant strains as *montinus* in New Hampshire, *boisduvalii* in Labrador and the subarctic regions, *grandis* in southern Canada, *rainieri* in Washington, *ingens* in Idaho, Montana and Wyoming, and *helena* in Colorado, Utah and New Mexico, is thus easily understandable, and presents a simple and plausible explanation of the presence of these more or less inter-related "races."

In such a case none of these forms just mentioned need be considered as ancestral to any of the others; all may be considered as divergent to a greater or lesser degree from a common, ancestral *c. chariclea-c. arctica* stock. Furthermore we must not assume that the mere accident of geographic contiguity will produce the same or close evolutionary results; for in so doing we would ignore many possibilities of divergence through the appearance of mutants. And this being so there is nothing surprising in the fact that the southernmost member of this complex, *helena*, should show a greater resemblance to the northernmost, *arctica*, than do the intermediate ones, *grandis*, *rainieri* and *boisduvalii*; or that in a population of *helena* there should occasionally arise by fortuitous combination an "atavistic" individual such as the one described above.

The same phenomenon of close similarity of a southern and an arctic race has been noted before in this paper in the case of *B. aphirape*, races *triclaris* and *alticola*. It is possible that the same explanation may apply there.

#### **Brenthis helena ingens B. & McD.**

A considerable series of *helena* taken in northwestern Wyoming (vic. Green River Lake, July 24-Aug. 7 and Middle Piney Lake and Wyoming Peak, August 9-12) may be referred to the race *ingens* B. & McD., described from the Yellowstone Park, although these specimens are not as entirely typical of this race as specimens from further north. The average length of fore-wing in a series of 34 males of *h. helena* from Colorado was found to be 18.95 mm, as contrasted with an average length of 21.08 mm in a

series of 21 males from the Wind River and Wyoming Ranges, which would place the latter series in *ingens* on size alone. In other characters they also agree with *ingens* rather than with *h. helena*.

*Ingens* appears to be a valid race of *helena*, though not an extremely distinct one; the characters cited in the original description all seem to hold true in series.

Judging from the material I have studied, *helena* does not intergrade to *chariclea* its nearest relative, through *ingens*, as might be expected from topographic data; instead there appears to be a closer resemblance between *h. helena* from Colorado and Utah and *c. rainieri* from Washington than between the geographically more contiguous *h. ingens* of Montana and *c. grandis* of Alberta. Study of more material from Montana, Idaho and southern Alberta may, of course, demonstrate the reverse to be true.

#### Brenthis freija Thunberg

Specimens of *freija* were taken at Hall Valley July 14-15, and in the Snowy Range July 17-23. In all cases they were in extreme upper Canadian and Hudsonian Zones, flying in grassy bogs and meadows. With the exception of one female from the Snowy Range all were rather badly worn, which bears out a previous conclusion of mine that *freija* is the earliest species of Rocky Mountain *Brenthis* to be on the wing. On June 8, 1933, a specimen of *freija* was taken by me on Pikes Peak, in middle Canadian Zone meadow, at 8700 ft. altitude, when no other butterflies were yet flying. This record is, incidentally, of additional interest, as being the only case known to me of a *freija* occurring below the uppermost Canadian Zone.

Dark specimens of *freija* are often erroneously identified as *tarquinius* Curtis, probably largely because of unfamiliarity with the true *tarquinius*. Study of series from Greenland and Baffinland shows that this name should be restricted to specimens from such extreme Arctic regions as these, where the population is predominantly large in size, with very heavy fuscous and chocolate-brown markings and suffusions. I have never seen a southern specimen of *freija*, even in a large series from Churchill, Manitoba, which was not easily distinguishable from the true *tar-*



*quinus*; although doubtless very rare accidents do occur. A considerable series from interior Alaska which I have examined are all to be classed as *freijsa* rather than as *tarquinius*. *Natazhati* Gibson, also from Alaska, is of course distinct, but is to be considered as a race of *freijsa* rather than as a distinct species as is sometimes done.

### ***Brenthis epithore* Edwards**

The eastward limits of the range of this species are unknown to me. Holland records the species in the "Butterfly Book" from "as far East as Colorado," but inasmuch as he considered *sagata* Barnes and Benjamin to be conspecific with *epithore*, this is not to be taken too seriously. I have one specimen from an unknown, old collection labelled "Steamboat Landing, Colorado," but the data on this may be erroneous. It is certain that if it does occur in the Great Basin and Rocky Mountain regions, *epithore* must be very rare east of the Sierras.

### ***Brenthis frigga* Thunberg**

The southern distribution of *B. frigga saga* Stdgr., and all the limits of distribution of *B. frigga sagata* Barnes & Benjamin are not known, and I would very much appreciate any information on the subject. In the Butterfly Book (rev. ed., p. 111) Holland errs in placing *sagata* as a synonym of *epithore*. I have seen the types and other Colorado specimens of *sagata*, and do not hesitate to state that it is unquestionably a valid, small-sized race of *frigga*, and as such is perfectly distinct from any other species of *Brenthis*.

Intensive collecting at the type locality, Hall Valley, failed to produce any specimens of *sagata* in 1935, although we were there at the right time. Possibly it occurs in some very limited environment, which we missed.

*Bugs, Birds and Blizzards in the Yellowstone.* By Harlow B. Mills. Collegiate Press, Inc., Ames, Iowa, 1937. 9 × 6 in., vii + 76 p., stiff paper covers, wire binding, \$0.50.

This is an interesting account of the things to be seen in Yellowstone Park, which are not seen at all by the average visitor. It was written by a naturalist, of which there are so few real ones these days. Rocks, rivers, insects, birds, beasts, trees, sunsets, people, food, warmth, shelter, and everything that enters a complete life in the open, impinged themselves upon the consciousness of Dr. Mills, and with his appreciation of the background that lies behind seemingly simple things, he has woven them into a fascinating and intensely personal narrative which all good naturalists will enjoy reading. I would rather sit at home and read this account than go to Yellowstone Park and see only "Old Faithful and a mangy bear."—H. B. W.

*The Sacred Bee in ancient times and folklore.* By Hilda M. Ransome. 8.5 × 5.5 inches, 308 p., 12 pl., 35 figs. Boston and New York, Houghton Mifflin Company, 1937. \$3.50.

This book is packed from cover to cover with interesting and fascinating information about bees and beekeeping from early times down to about the middle of the nineteenth century. The author traces the history of beekeeping through Ancient Egypt, Babylonia, Assyria, India, China, Greece, Italy, and various countries of Europe and writes in some detail of the use of bees and honey in connection with the religious, domestic, mythological and artistic life of the various inhabitants. Myths, folklore, customs, legends and superstitions, all connected with bees, crowd the pages of this book, together with illustrations as interesting as the text. And there is even a chapter about the bee in America, devoted chiefly to practices by the Maya.

There is no doubt about this book finding its way into all the entomological libraries of the country. And there are thousands of beekeepers, who, theoretically, should each own a copy, but I fear that the practical beekeepers as a group are no more interested in the historical and cultural sides of beekeeping than peanut vendors are interested in the history of peanuts.—H. B. W.

THE NORTH AMERICAN SPECIES OF NEMADUS  
THOM., WITH DESCRIPTIONS OF NEW SPECIES (COLEOPTERA, SILPHIDÆ)\*

BY H. C. FALL

TYNGSBORO, MASS.

The genus *Nemadus*, erected in 1859 by C. G. Thomson for a small number of species of the silphid tribe Catopini, seems not to have been looked upon with favor by his contemporaries, nor was it accepted by Horn in his Synopsis of the North American Silphidæ in 1880. Horn was familiar with Thomson's work and in general regarded it highly, but evidently did not consider the characters on which *Nemadus* was founded as of more than group value within the genus *Ptomaphagus*. *Nemadus* however is given generic recognition in late European Check Lists and is used by Dr. H. M. Hatch in his recent paper—"Studies on the Leptodiridæ (Catopidæ)," (Journ. N. Y. Ent. Soc., Mar.-Jun., 1933). In this paper, *parasitus* Lec., *pusio* Lec., and *horni* Hatch n. sp. (previously confused with *pusio*) are referred to *Nemadus*, based on the following characters.

Pronotum not transversely strigose; apex of hind tibia with rather long unequal spinules; basal joint of middle tarsus of male slightly dilated and spongy pubescent beneath.

Long before his death in 1912, my lamented friend Frederick Blanchard, of Tyngsboro, Mass., became greatly interested in the collection and study of his local species of *Ptomaphagus*. I quote the following from his note book under date May 27, 1894.

"Besides the very common *parasitus*, occurring abundantly with a black ant (*Formica subsericea* Say) under stones, and the

\* A short time before the present paper was prepared and submitted for publication, there appeared in the Memoirs du Museum National D'Histoire Natural (Paris, 1936), a Monograph of the Catopidæ by Dr. R. Jeannel. This work has only recently come to my attention and I have not as yet been able to determine whether any synonymy is involved.

very rare *brachyderus* which lives with *Camponotus pictus* in pine logs and stumps, there are three other species which seem to be more or less common.

"1. With *Formica exsectoides*, the mound building ant, there is a rather large species at once known by the obliquely narrowed elytra and the more slender antennal club. 2. With *Formica integra*, an ant much like *exsectoides* but rather more robust, not mound building, discharging a tiny stream of formic acid when disturbed, occurs a *Ptomaphagus* with sides of elytra broadly rounded as in *parasitus*. This species is larger than *parasitus*, with a broader thorax, the disk similarly clouded, both sexes shining. 3. With *Camponotus pictus* and *C. pennsylvanicus* occurs a species rather larger and broader than *parasitus*, easily known by the prothorax always without fuscous cloud, the strigæ of the elytra finer and closer, pubescence thin and fine, male shining, general color more castaneous or reddish brown than in *parasitus*."

These three species all agree with *parasitus* in those characters which indicate the genus *Nemadus*, and in my opinion all are valid species. Examples of all these were included in a large lot of more than one hundred specimens sent by Mr. C. A. Frost to Dr. Hatch, who however failed to differentiate them from *parasitus*.

The following tabular synopsis is offered for the separation of the six species here recognized. The descriptions of the new species are quite brief, embodying little more than those characters which are of diagnostic value.

Types of the new species are in the writer's collection. Paratypes of all are in the Blanchard collection.

#### TABLE OF SPECIES

- |   |   |
|---|---|
| 1. Elytra broadly rounded on the sides, at most only moderately attenuate posteriorly; pronotum more or less clouded with fuscous (except <i>pusio</i> ) .....  | 2 |
| Elytra strongly attenuate, the sides less arcuate .....   | 5 |
| 2. Form rather narrow and more evenly oval, widest at about the middle of the length; average size somewhat smaller; eighth antennal joint less than half as long as the ninth and at least twice as wide as long ..... | 3 |
| Form a little broader and more ovate, the point of maximum width a little before the middle of the length, the elytra moderately attenuate  |   |



- though with rounded sides; eighth antennal joint much less disk like, always less than twice as wide as long, and usually nearly or quite one-half the length of the ninth joint ..... 4
3. Both sexes with alutaceous sculpture between the elytral strigæ; elytral strigæ less oblique, nearly transverse. California; British Columbia ..... *pusio* Lec.  
Male without, female with alutaceous sculpture between the elytral strigæ (Mass. to Mich., Colo. and Fla.) ..... *horni* Hatch
4. Elytra shining in the male, alutaceous and duller in the female; size smaller but averaging a little larger than in the two preceding species ..... *parasitus* Lec.  
Elytra in both sexes shining and without alutaceous sculpture; size distinctly larger ..... *integer* n. sp.
5. Antennal club very slender, joints 7, 9 and 10 conspicuously longer than wide; pronotum always more or less clouded with fuscous. .... *gracilicornis* n. sp.  
Antennal club less slender, joints 7 and 9 little if any longer than wide, 10 as wide or wider than long; pronotum never with dorsal cloud ..... *obliquus* n. sp.

### **Nemadus pusio Lec.**

Of this small species I have seen only the type in the Le Conte collection. It is a female, 1.6 mm. in length, reddish brown in color the head darker, outer four joints of antennal club piceous, the terminal joint paler at tip. It was taken at Point Reyes, on the coast a short distance north of San Francisco, California. Other recorded localities range from Los Gatos in the Santa Cruz Mts. south of San Francisco (Hatch) to Vancouver, B. C. (Horn). It is our only known Pacific Coast species.

### **Nemadus horni Hatch**

This name is given by Hatch to the specimens occurring in the Eastern States, which hitherto have been referred to *pusio*. These differ from *pusio* in having the pronotum more or less piceous, the elytral strigæ slightly more oblique, and with alutaceous sculpture between the strigæ only in the female. In the twenty-three examples which I have examined the antennæ are sometimes unicolorous but more often with darker club, in which case the terminal joint is more or less pale. In length they scarcely vary from 1.75 or 1.85 mm. Hatch gives 2.2 mm. as the upper limit, which is so extraordinary as to suggest the possibility of error. This species is widely dispersed, ranging from

New England to Alabama and west to the Mississippi River. The type locality is Framingham, Mass.

### **Nemadus parasitus** Lec.

The type of this common species is a male, 1.9 mm. long, from "N. Y." The LeConte series contains three other N. Y. specimens, two from "D. C." and two without locality labels. The average size is perceptibly greater than in the two preceding species but rather less than in the three which follow. The color varies from a yellowish brown to castaneous, the pronotum more or less clouded with fuscous. The form is a trifle broader than in *pusio* and *horni*, the elytra are broadly arcuate on the sides and only moderately attenuate.

In his remarks under this species Hatch says that it closely resembles *Dissochaetus brachyderus* Lec. This is equivalent to saying that the elytra are strongly attenuate behind, which is never the case in the true *parasitus*, and shows conclusively that the author confused therewith two of the species which follow, viz. *gracilicornis* n. sp. and *obliquus* n. sp.

*Parasitus* is more widely dispersed than any other of our species, occurring, if the records can be trusted, from Quebec to Manitoba and Colorado and south to Virginia and Texas.

### **Nemadus integer** new species

Strikingly similar to *parasitus* but generally of larger size, as is quite evident when series are compared. The color is reddish brown, the disk of the pronotum with fuscous area of variable extent; antennal club not infusate, 8th joint about one-half the length of the 9th and much less than twice as wide as long. Elytra broadly rounded on the side and only moderately attenuate posteriorly, as in *parasitus*; surface polished and without micro-sculpture between the strigæ in either sex. Length 2.1 to 2.25 mm.

More than thirty examples have been examined, mostly in the Blanchard collection. The type is a female bearing label "Lowell Ms." but was undoubtedly taken in Tyngsboro, as were all the Blanchard specimens; a single female from Framingham, Mass., is in my collection.

The absence of alutaceous sculpture between the strigæ of the elytra in both sexes is the most important diagnostic character of this species as is indicated in the preliminary remarks.

Blanchard's specimens were always taken with a different ant from that with which *parasitus* occurred.

***Nemadus gracilicornis* new species**

Broader anteriorly than in *parasitus*, the elytra more strongly attenuate, the size distinctly larger. The color is reddish brown, the head piceous, the pronotal disk more or less broadly infusate, antennal club not darker. The antennal club is more slender than usual, joints 7, 9 and 10 conspicuously elongate, these being at most but slightly longer than wide in *parasitus*; 8th joint about half the length of the 9th and scarcely one-half wider than long. Elytra widest near the base, the sides thence but little arcuate and strongly converging to apex; interstrigal surface smooth or very nearly so in the male, distinctly minutely alutaceous and less shining in the female. Length 2.1 to 2.3 mm.

Some forty specimens of this species have been examined. They bear labels—Massachusetts (Tyngsboro; Framingham; Natick); Connecticut (Cornwall); New Jersey (Ramsey); Manitoba (Aweme). The type is a male from Cornwall, Conn. (K. C. Chamberlain) and bears date "23, IV, 1922."

The more slender antennal club, fuscous pronotal area, and subtriangular elytra form a combination of characters which distinguish this species from all others in the genus. The elytra are nearly as strongly attenuate as in *brachyderus* but lack the lateral subapical sinuation present in that species.

***Nemadus obliquus* new species**

Broadly ovate, the sides of the elytra strongly convergent from near the base. Color uniformly reddish brown or castaneous, the pronotum never with any trace of discal cloud. Antennæ concolorous, 7th and 9th joints varying from nearly as long to slightly longer than wide, 8th about half the length of the 9th but a little variable, 10th rarely if ever as long as wide. Elytra strongly wedge shaped, about one-third longer than wide, sides very broadly arcuate; surface shining in the male, the interstrigæ not or scarcely visibly alutaceous, perceptibly alutaceous and duller in the female. Length 2.0 to 2.25 mm.

The size is a little larger than in *parasitus* but somewhat smaller than in *integer* or *gracilicornis*, and is proportionately broader than in either of them. The absence of pronotal cloud at once separates this species from all other normally colored eastern members of the genus, and the strongly cuneiform elytra distinguish it from all but *gracilicornis*, in which the antennal club is a little more slender with the 10th joint always longer than wide.

I have studied or passed in review more than forty specimens of this species, the larger number being in the Blanchard collection. The type is a female taken by myself at Tyngsboro, Massachusetts, VI-2-1925. Other localities represented are Dracut and Framingham, Mass.; Newark and Montclair, New Jersey; and Philadelphia, Pa. (Liebeck Coll.).





## THE USE OF HONEY BEES FOR TESTING LIQUID INSECTICIDES\*

BY FRANKLIN C. NELSON

STANCO, INCORPORATED

During the month of August, 1925, the writer was called upon to find an insect which would be suitable for testing liquid insecticides and at the same time be readily available throughout the year. A number of insects were tried out but most all of them were unsatisfactory for various reasons. House flies (*Musca domestica*) and biting stable flies (*Muscina stabulans*) were reared and gave satisfactory results in the tests but due to a lack of space and poor heating conditions, it was impossible to carry them through the winter.

It was finally decided that honey bees (*Apis mellifera*) were the most readily available and possessed a degree of sensitivity that should lend itself readily in the detecting of differences in concentration of a nerve poison such as pyrethrum. A hive of bees was therefore brought into the laboratory for preliminary test work. Small screen wire "Hodge type" fly cages were purchased for the handling of the bees during treatment. These were 5" in diameter across the bottom and about 4" high at the peak of the cone top. They consisted of two separate parts, as shown in figure 1.

In the center of the bottom or inner cone of the cage, a small hole was made just large enough to allow the bees to enter. All cages were waxed with hot paraffin before use as it was found that the bees died in a few hours without any spray treatment at all if placed in cages not so waxed. Just why this occurred was not determined but they were seen to bite on the iron wire quite viciously and they must have gotten something from the wire to cause their death. The waxed cages seemed to prevent most of

\* The work reported in this paper was done as a part of a project administered by the Crop Protection Institute, financed by Stanco, Incorporated, and carried out in cooperation with the Department of Entomology of Rutgers University.

this chewing. Using honey as a food, caged bees in waxed cages lived for several days. The waxing was done by heating the paraffin until liquefied, then the cages were dipped in the hot wax and immediately blown with air to remove the excess wax from the wire openings, leaving a thin coating on the wire. All cages were burned and rewaxed after each test in order to remove any liquid spray remaining on the cage.

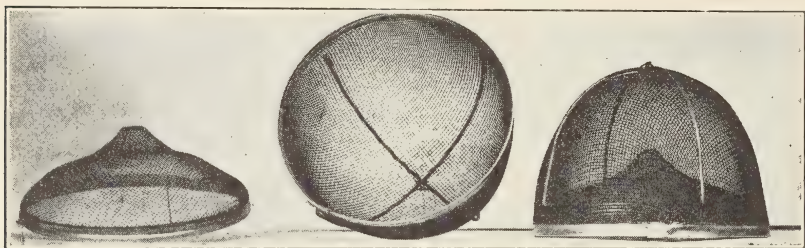


FIG. 1

## HANDLING THE BEES

When the hive of bees was brought into the laboratory, it was placed by a window and a runway was fixed in the entrance, which allowed the bees free access to the out-of-doors on warm days in winter, as well as during the summer. A tight inner cover was nailed on the top of the hive before it was brought in and the center hole of this cover was fitted with a sliding door and cone wire runway which extended upward about 4". The wire cages were placed on this runway and the cover opened to allow the bees to run into the cage. The bees in a new, well-stocked hive rushed out freely and found their way almost at once into the cage above. After about ten bees had entered the cage, it was quickly removed and an empty one put in its place. This was readily done without allowing any bees to escape, if care and speed were used in the transfer. This procedure was continued until enough cages were filled to run a complete test. The number of cages depended, of course, on the number of samples to be tested. As each cage was filled, a daub of honey was placed on the top of the cage for food and a small cork was fitted into the entrance hole to prevent the bees from escaping. When the bees refused to run out of the hive readily, the hive was jarred sharply

or a long wire was run in from the top in order to stir them up and cause them to run out. After the hive was somewhat depleted, it then became necessary to remove the inner cover and pick the bees out with a small forceps, placing them one by one in the wire cages. This was done without harming the bees by picking them up by the legs and quickly placing them in the cage. If there was any fear of being stung while handling them, the operator wore a bee veil and long canvas bee gloves. Any one at all familiar with bee habits should have no difficulty in the handling of them for this work. After enough cages were ready they were lined up on a testing table or rack within easy reach of the operator. The most convenient grouping was found to be several shelves one above the other so arranged that a single row of cages, set out on each shelf, facilitated both spraying and later readings.

#### SPRAYING EQUIPMENT

The delivery of the spray material was controlled in every way possible in order to eliminate variations due to equipment. An air compressor and reserve tank were used with an automatic control to maintain fairly uniform pressure. Oil and water separators were also used to keep the air dry and the sprayer from clogging. An air control valve of the Hoke type was set at three pounds' pressure for the proper maintenance of the air pressure. The atomizer used was the Weber Indestructible #2. These were rebuilt to suit the particular need for this job by closing up the liquid tube in the top and redrilling a smaller hole. These atomizers were extremely simple and were adaptable for downward spraying. No doubt other suitable sprayers may now be found that will direct the spray downward but at the time this method was devised there seemed to be nothing more suitable at a low price.

The spraying apparatus consisted of the following: a small square box  $4\frac{1}{2}$ " high and 9" square which formed a base for the glass cylinder. The corners of this box were open to allow free passage of air and spray particles. This was fastened securely by screws to one corner of a table. On the top of this box was nailed a round cover 12" in diameter by  $\frac{5}{8}$ " thick with a hole in



the center approximately  $4\frac{3}{4}$ " in diameter and just large enough to hold the bee cage when turned upside down in the spraying position without allowing it to fall through. On top of this cover was placed a pyrex glass cylinder open on both ends and 12" high and  $9\frac{1}{2}$ " in diameter. This was held in place by nails on four sides of the cylinder. The use of this round glass cylinder prevented air currents from blowing the fine spray particles away from the cage. On one side of this arrangement an iron ring stand was fastened to the table to form a support for the sprayer. This stand was 36" high with a  $\frac{5}{8}$ " upright rod. A clamp and extension arm was fastened to this 2" above the top of the glass cylinder and directly over the cage and in this clamp was fastened the small atomizer previously described. All of this equipment was fastened securely to prevent it from shifting during the spraying process. This equipment is shown in figure 2, and 2A. 2A is just a close-up view of the actual spraying equipment which does not show plainly in figure 2.

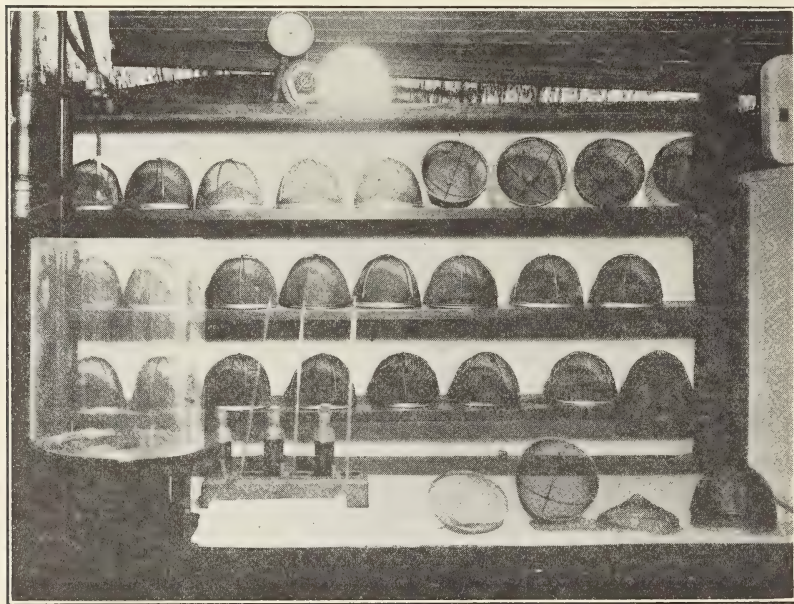


FIG. 2



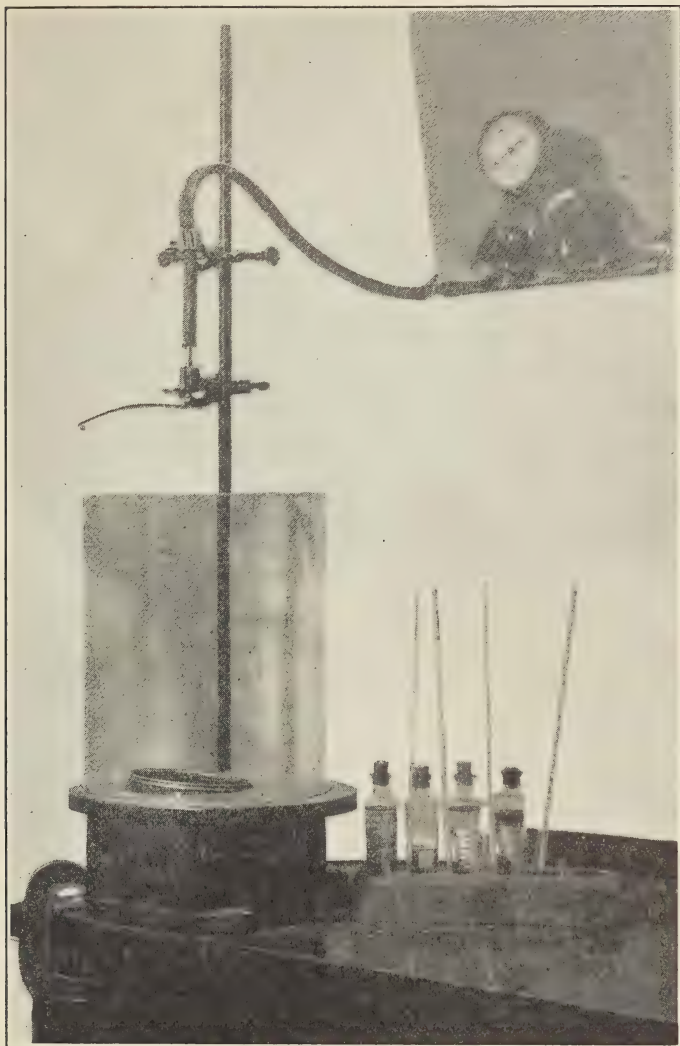


FIG. 2A

In centering the sprayer so that the spray was directed at the exact center of the cage, pieces of white blotting paper were used and colored liquid sprayed on them until the exact center was located. The sprayer was then locked in position and rechecked

for centering. Small round-bottom vials were used to measure out the liquid to be sprayed. They were first carefully calibrated by means of an accurate pipette and each dosage was clearly marked on the side of the vial for later measurements. These were only used where one or two dosages were needed for each sample. In other tests requiring more accurate results and where more dosages were used, small pipettes were used for all measurements. In any case, an individual vial or pipette was used for each sample to eliminate the necessity of cleaning such measuring vials between sprayings. A rack was made to hold the sample bottles and vials in order to prevent the vials from getting mixed up with the wrong samples and to prevent spilling. This is shown in figure 2.

#### SPRAYING PROCEDURE

Several variations in procedure have been used from time to time depending upon results desired but only two types of methods will be described at this time. For ordinary quick indications not demanding too accurate results, only one dosage was used per sample and a total of 400 bees or 40 cages per sample. In this test 0.8 cc. of Flit was found to give close to the 50 per cent. kill figure and was used as a standard dosage. Each sample was alternated and a cage sprayed every minute, for example, sample #1 at 8 o'clock, #2 at 8:01, #1 at 8:02, #2 at 8:03, etc., until 80 cages were sprayed. Readings were also taken at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, as well as 24 hours. The 30-minute reading was not always taken, but was used mainly on very strong samples. This meant that after 30 cages were sprayed a reading and a spraying had to be done every minute until the cages were all sprayed. This could readily be done with a little experience. It might have been unnecessary to make five observations but the writer felt that a more accurate picture could be drawn from several readings rather than from only one or two. These individual time readings were then averaged for the entire test and graphs were drawn up to show just what the test indicated. The details of this will not be gone into at this time as they are more carefully considered later.

The second, and more accurate method employed, required the use of several dosages per sample and, using an insecticide such

as Flit, the dosages that worked out most satisfactorily were 0.1 cc., 0.3 cc., 0.5 cc., 0.7 cc., and 0.9 cc. per cage. Observations were again made at 30 min., 1 hour, 2 hours, 4 hours, 6 hours and 24 hours. Pipettes of 1 cc. capacity were used for measuring these dosages as the volume of liquid was much too small to allow ordinary measuring in a tube. The measured liquid was placed in the smallest vial available that would work satisfactorily on the atomizer. The dosages and samples were alternated in regular rotation, for example, 0.1 cc of #1, 0.1 cc. of #2, etc., and then 0.3 cc. of #1, 0.3 cc. of #2, until all the dosages were completed for the series. They were then repeated in the same rotation until the entire test was finished. In this test, 480 bees were required per dosage or a total of 2,400 bees per sample. This represented a large amount of work but the results obtained could be depended upon without the question of doubt that might arise in a test less complete.

The amount of time necessary to complete a test of this type was longer than desirable for conditions that called for large numbers of tests, but if accuracy rather than speed was desired, the method was found to be very satisfactory, especially for research samples. A great deal of the time in this test was taken up by filling the cages with bees, getting equipment ready from day to day such as burning off the wax and other details involved in the test. With, for example, two samples to be run, an operator sprayed 60 to 80 cages per day and as these carried over for the 24-hour reading, it was necessary to supply at least 160 cages for one tester. The time necessary to complete this test ran from 6 to 8 days, depending on the speed and experience of the operator. If he could spray more than 80 cages per day, it, of course, required less time to complete the test. Aside from the speed of the operator, the number of cages sprayed per day depended on the ease and speed with which the bees could be caged, as well as the speed in burning and rewaxing cages. Readings were recorded day by day on specially printed record sheets as shown in figure 3.

The 30-minute period is not shown as it was not always used and was written in when desired. Only the heading "Dead" was used on these records to facilitate the reading. After all

OP-760  
OPERATOR

M.F.

C. C. PERCENTAGE

1/10, 5/10, 5/10

CONTROL REPORT

TEMPERATURE °F

Humidity

82°

67%

SERIES No. 559

7/10, 9/10 cc

SAMPLE A

DATE RUN 8/10/30

SAMPLE B

PAGE 1

TIME RUN 9:00 A.M.												DEES	TIME RUN 9:10 A.M.												DEES
1/10 cc.												10	1/10 cc.												10
30 min.	0	DEAD	0%	6 HRS.	0	DEAD	0%	6 HRS.	0	DEAD	0%	30 min.	0	DEAD	0%	6 HRS.	0	DEAD	0%	6 HRS.	0	DEAD	0%		
1 HRS.	0	"	0%	"	0	"	0%	"	0	"	0%	1 HRS.	0	"	0%	"	0	"	0%	"	0	"	0%		
2 "	0	"	0%	"	0	"	0%	"	0	"	0%	2 "	0	"	0%	"	0	"	0%	"	0	"	0%		
4 "	0	"	0%	"	0	"	0%	"	0	"	0%	4 "	0	"	0%	"	0	"	0%	"	0	"	0%		
6 "	0	"	0%	"	0	"	0%	"	0	"	0%	6 "	0	"	0%	"	0	"	0%	"	0	"	0%		
O. N. 1						10%	O. N. 0						0	O. N. 0						0					
TIME RUN 9:01 A.M.												10	TIME RUN 9:11 A.M.												10
5/10 cc.												10	3/10 cc.												10
30 min.	0	DEAD	0%	6 HRS.	0	DEAD	0%	6 HRS.	0	DEAD	0%	30 min.	0	DEAD	0%	6 HRS.	0	DEAD	0%	6 HRS.	0	DEAD	0%		
1 HRS.	0	"	0%	"	0	"	0%	"	0	"	0%	1 HRS.	0	"	0%	"	0	"	0%	"	0	"	0%		
2 "	0	"	0%	"	0	"	0%	"	0	"	0%	2 "	0	"	0%	"	0	"	0%	"	0	"	0%		
4 "	0	"	0%	"	0	"	0%	"	0	"	0%	4 "	0	"	0%	"	0	"	0%	"	0	"	0%		
6 "	0	"	0%	"	0	"	0%	"	0	"	0%	6 "	0	"	0%	"	0	"	0%	"	0	"	0%		
O. N. 0						0	O. N. 0						0	O. N. 1						10					
TIME RUN 9:02 A.M.												10	TIME RUN 9:12 A.M.												10
5/10 cc.												10	5/10 cc.												10
30 min.	0	DEAD	0%	6 HRS.	0	DEAD	0%	6 HRS.	0	DEAD	0%	30 min.	0	DEAD	0%	6 HRS.	5	DEAD	50%	6 HRS.	5	DEAD	50%		
1 HRS.	0	"	0%	"	0	"	0%	"	0	"	0%	1 HRS.	0	"	0%	"	5	"	50%	"	5	"	50%		
2 "	0	"	0%	"	0	"	0%	"	0	"	0%	2 "	0	"	0%	"	5	"	50%	"	5	"	50%		
4 "	0	"	0%	"	0	"	0%	"	0	"	0%	4 "	0	"	0%	"	5	"	50%	"	5	"	50%		
6 "	0	"	0%	"	0	"	0%	"	0	"	0%	6 "	0	"	0%	"	5	"	50%	"	5	"	50%		
O. N. 0						0	O. N. 0						0	O. N. 5						50%					
TIME RUN 9:03 A.M.												10	TIME RUN 9:13 A.M.												10
7/10 cc.												10	7/10 cc.												10
30 min.	0	DEAD	0%	6 HRS.	7	DEAD	70%	6 HRS.	7	DEAD	70%	30 min.	0	DEAD	0%	6 HRS.	7	DEAD	70%	6 HRS.	7	DEAD	70%		
1 HRS.	0	"	0%	"	7	"	70%	"	7	"	70%	1 HRS.	0	"	0%	"	7	"	70%	"	7	"	70%		
2 "	4	"	40%	"	7	"	40%	"	7	"	40%	2 "	0	"	0%	"	7	"	70%	"	7	"	70%		
4 "	6	"	60%	"	7	"	60%	"	7	"	60%	4 "	0	"	0%	"	7	"	70%	"	7	"	70%		
6 "	6	"	60%	"	7	"	60%	"	7	"	60%	6 "	6	"	60%	"	7	"	70%	"	7	"	70%		
O. N. 10						100%	O. N. 10						100%	O. N. 9						90					
TIME RUN 9:04 A.M.												10	TIME RUN 9:14 A.M.												10
9/10 cc.												10	9/10 cc.												10
30 min.	0	DEAD	0%	6 HRS.	10	DEAD	100%	6 HRS.	10	DEAD	100%	30 min.	0	DEAD	0%	6 HRS.	10	DEAD	100%	6 HRS.	10	DEAD	100%		
1 HRS.	0	"	0%	"	10	"	100%	"	10	"	100%	1 HRS.	0	"	0%	"	10	"	100%	"	10	"	100%		
2 "	0	"	0%	"	10	"	100%	"	10	"	100%	2 "	0	"	0%	"	10	"	100%	"	10	"	100%		
4 "	0	"	0%	"	10	"	100%	"	10	"	100%	4 "	0	"	0%	"	10	"	100%	"	10	"	100%		
6 "	0	"	0%	"	10	"	100%	"	10	"	100%	6 "	0	"	0%	"	10	"	100%	"	10	"	100%		
O. N. 10						100	O. N. 10						100	O. N. 10						100					

FIG. 3

the tests were completed, the results were tabulated under each dosage and at each reading period. For example, with the 0.1 cc. dosage the results were tabulated for the 30-minute reading, then the hour, two hour, etc. The same procedure was carried out with 0.3 cc. dosage and all the others. Each of these sets of readings was then averaged and this average was used as one point for establishing a representative graph for each dilution. Some of these results are shown in the set of figures that follow for one dilution which was taken from an actual test set to show just what was done. Graph No. 1 following this record sheet is based on the same test and represents a complete set of five sheets for each sample similar to the one shown here and covers all dosages involved.

The following graph is based on the above summary of per cent dead for each dosage and time reading and gives a very clear picture of results that may be expected from the same insecticide at varying concentrations as well as the comparative picture between two different insecticides.



SAMPLE SHEET SHOWING ALL READINGS ON INDIVIDUAL CAGES OF SAMPLE A.  
SIMILAR SHEETS ARE MADE FOR THE OTHER DILUTIONS OF  
SAMPLE A AND ALSO FOR SAMPLE B

*Dead*

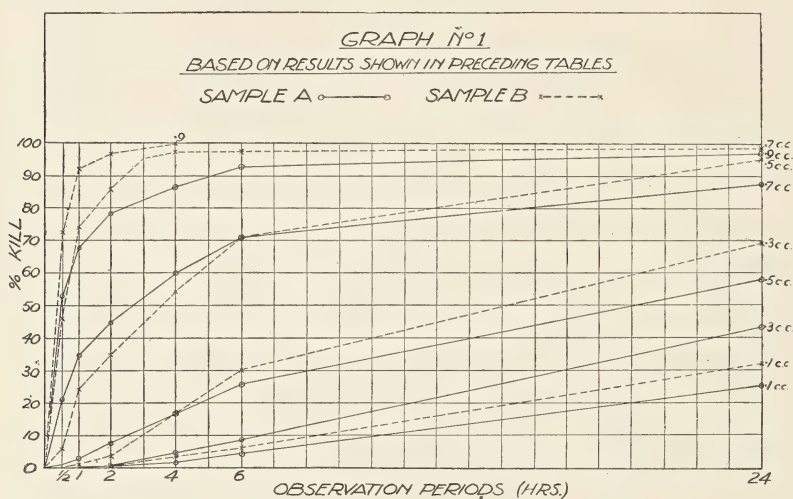
cc. Used	30 Min.	1 Hour	2 Hours	4 Hours	6 Hours	24 Hours	Total bees per cage
1/10 cc. per cage	0	0	0	0	0	5	10
	0	0	0	0	0	5	10
	0	0	0	0	0	4	10
	0	0	0	0	0	4	10
	0	0	1	1	1	1	10
	0	0	0	0	0	2	10
	0	0	0	0	0	0	10
	0	0	0	0	3	0	10
	0	0	0	0	1	6	9
	0	0	0	1	1	7	10
	0	0	0	0	5	1	10
	0	0	0	1	0	6	10
	0	0	0	0	0	4	10
	0	0	0	0	0	4	10
	0	0	0	0	0	4	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	2	10
	0	0	0	0	2	5	10
	0	0	0	0	2	6	10
	0	0	0	0	2	6	10
	0	0	0	0	1	5	10
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	8
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	1	1	1	1	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	10
	0	0	0	0	0	2	10
	0	0	0	0	0	2	10
	0	0	0	0	0	7	10
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
	0	0	0	0	0	1	10
	0	0	0	0	1	2	10
	0	0	0	0	0	0	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	11
	0	0	0	0	0	0	9
	0	0	0	0	0	2	10
	0	0	0	0	0	4	11
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
No. Dead .....	0	0	2	4	20	118	478
Per cent Dead ...	0	0	0	1	4	25	

*Summary of per cent dead of all dosages for Sample A*

cc. Used	30 Min.	1 Hour	2 Hours	4 Hours	6 Hours	24 Hours
1/10 cc. ....	0	0	0	1	4	25
3/10 cc. ....	0	0	0	4	8	43
5/10 cc. ....	1	3	8	17	26	58
7/10 cc. ....	21	35	45	60	71	88
9/10 cc. ....	53	68	79	87	93	98

*Summary of per cent dead of all dosages for Sample B*

1/10 cc. ....	0	0	0	3	6	32
3/10 cc. ....	0	1	4	17	30	69
5/10 cc. ....	7	24	35	54	71	96
7/10 cc. ....	48	74	87	96	98	99
9/10 cc. ....	73	92	98	100	100	100



## DISCUSSION

I have attempted in the preceding figures and description to give an accurate working picture of the method of using honey bees for laboratory testing work. In reviewing the preceding graph, it is evident at once why a low or a high concentration with a resulting low or high kill is unsuitable for comparative testing work. If one looks at the 1/10 cc. dosage, for instance, he will see that the difference between these two samples is well within experimental error both as the 24-hour reading and at all the other periods of observation. The 3/10 cc. dosage comes

somewhat nearer to being a satisfactory concentration in that it falls above and below the 50 per cent. point. It does not, however, show the wide-spread difference between the two samples that the middle dosage or 5/10 cc. does.

The 7/10 cc. and 9/10 cc. results taper off after reaching a fairly high toxicity in six hours and again these would be unsuitable for comparison work by themselves as the difference between the samples with these concentrations narrows down to experimental variation at the 24-hour reading. By using a series of concentrations such as shown here, it is possible, however, to obtain a very clear picture of what is happening and if by any chance the insecticides should be very poor or unusually strong, at least one or two of the concentrations would fall in the optimum point of comparison and the test would therefore be acceptable.

The speed of paralysis is, of course, not shown at all but one can obtain a fair picture of speed of kill, which is also valuable and would probably, to some extent, fall in line with a similar paralysis figure. An additional observation might be added to the method to determine speed of paralysis based on time elapsed between spraying and the point when all bees were on the bottom of the cage.

All of this, of course, takes a great amount of time both in the actual spraying operations as well as in the calculations of results but when a sample is completed there is little room for doubt as to exactly what may be expected. It is because of this accuracy that we have felt justified in using a complicated test of this sort.

It will probably be of value to point out at this time some of the advantages and disadvantages of the method.

#### ADVANTAGES

1. A steady supply of insects may be readily obtained throughout the winter months without the necessity of setting up a breeding laboratory. All insects are also of the same sex and about the same age, during winter months at least.

2. The insects are large, comparatively easy to handle and are very sensitive to most nerve poisons.

3. This method does not require the setting up of expensive testing rooms or other expensive testing apparatus.

4. It is a direct spray method and with the dosages divided up into such small amounts and sprayed on the bees directly, the chances of each bee receiving uniform amounts of liquid are probably better than in a "chamber" method.

5. The results obtained with this method have been shown to be very satisfactory for comparing intrinsic toxicity of two samples even though it is not a method that is directly comparable to field conditions.

6. The method can be readily adapted to testing emulsions simply by changing the liquid tip in the atomizer and spraying larger volumes of spray liquid. It can also be adapted to dusting tests although it is not, of course, quite as accurate as with liquids.

#### DISADVANTAGES

1. The method requires considerable time to complete a single test.

2. A great many people object to handling honey bees because of the danger of stinging.

3. Speed of paralysis cannot be as accurately determined as in a "chamber" test.

4. Honey bees are not household insects and the results obtained cannot be taken as an interpretation of actual field results. This is particularly true in regard to recovery. Honey bees that have been affected by a spray seldom ever completely recover, although they do live beyond the 24-hour period. With flies, the recovery is often high and such flies seem to return to complete normalcy in spite of the treatment. Honey bees also do not respond to the action of various types of hydrocarbons to the same relative extent as do flies and cockroaches, and for this reason the relative killing power of two insecticides may be somewhat different if determined by the bee method than if tested against flies.

In spite of the limitations shown above and even though this method has been almost entirely replaced in our own laboratories by other methods involving the use of some of the so-called "household insects," the writer feels that it has considerable merit as a laboratory test method and is worthy of presentation.



## JOURNAL OF NORTH-AMERICAN MOSS-MITES

BY ARTHUR PAUL JACOT

NORTH EASTERN FOREST EXPERIMENT STATION,  
NEW HAVEN, CONN.

Because of the rapid development of the study of the superfamily Oribatoidea, and the cost of figures, it has become necessary to name and describe some of these species in much more condensed form than has been my ideal. I have on file, however, a set of detailed sketches of these species, and will retain the types until opportunity presents itself to complete the descriptions. Lots, the numbers of which bear a capital F, are to be deposited at the National Museum; otherwise at the Museum of Comparative Zoölogy.

After a careful study of certain genera which include a holartic species, I find that in holartic species the notogastral bristles tend to occupy the same relative positions in each of the subspecies while subspecific differences occur in the modification of chitinous ridges or expanses, that is, the position of the bristles is more stable than the development of the chitinous ridges and spurs. Examples are *Tectocephus velatus* and *Oppia corrugata* (see below).

***Trhypochthonius silvestris* sp. nov.**

Differs from *T. americanus* (11) in that the pseudostigmatic organ head and the notogastral bristles are pointed, not blunt; and that bristles al are minute and simple; other bristles of notogastral disc short but barbed or bristled.

COTYPES: Thirty specimens from litter of isolated short-leaf pine stand two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F15.2.

***Nothrus silvestris* (22, p. 458, Pl. 7, Figs. 4)**

The following American specimens are identical with those from Regensburg: One specimen from cushion moss, upland swamp, East Village, Monroe, Conn.; taken March 23, 1919, slide 1913n4. Two specimens from grey-green moss on rock, upland

swamp woods, East Village; taken August 25, 1925, slide 2531n1. Six specimens from hemlock leaf mould, hill above state road, gorge, Sandy Hook, Conn.; taken June 24, 1926, slide 2613n1.

***Nothrus terminalis carolinae* subsp. nov.**

DIAGNOSTIC CHARACTERS: Differs from the species (2, p. 10, Pl. 1, Fig. 8) from Austin, Texas, in having abdomen more sharply rounded behind; bristles e3 more distant from f2; rostral bristles short, pointed; lamellar bristles much larger, clavate.

DESCRIPTION: Abdomen with deep, narrow, dorsal groove distant from edge about twice its width, four bristles along lateral edge, the second (b3) inserted on transverse plane slightly anterior to c1, the third (d3) inserted on transverse plane slightly posteriad of d1; e1 as approximate as a1, subequally distant from d1 as d1 is from c1, directed mesad and usually crossing near distal end; e2 between e1 and f2 but nearer f2; the humeral bristle is a3; a2 shorter than the others; altogether there are 13 bristles visible in dorsal aspect and two in ventral aspect (inserted on edge of notogaster), all these bristles as well as lamellar and interlamellar are smooth edged but have a couple of fine longitudinal lines; pseudostigmatic organs closely barbed.

COTYPES: Thirteen and fifteen specimens from closely browsed *Andropogon* pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slides 34F11C1 and -C2.

***Nothrus monodactylus* comb. nov.**

*Nothrus anauniensis monodactylus* (8, p. 381) from Columbia, Mo., is closely related to the above, possibly synonymous. It cannot be redetermined until material from the type locality and type habitat is studied.

***Camisia spinifer* (Koch)**

Specimens from the Asheville basin (N. C.) are identical with specimens from Regensburg. They differ from the figures of Michael (21, vol. 2, Pl. 48, Figs. 7-13) in that the rostral bristles have very short apophyses, the apophyses of the lamellar bristles are as long as the body of the large posterior apophyses, and that the posterior pair of mesal bristles (that is bristles a5) are lacking. Although Michael shows a bristle laterad of the second mesal pair (a2), I believe these to be the distal ends of b1 recurved to that position. Neither Nicolet (22) or Willmann (29, p. 110, Fig. 62) show such and none such occur in Regensburg specimens. Finally the specimens from western North Carolina have much longer bristles than figured by European Acarologists

and they are very irregularly roughened by barbules, thorns and minute apophyses. (in caustic-potash cleaned specimens). These asperities may be identical with what Michael calls "villous processes."

If Michael's figures are accurate the English Islands may be endowed with a distinct, insular subspecies. Fortunately the continent of North America (at least in the east) will not force a trinomial on our already burdensome nomenclature. *Pseudotritia ardua* and *Northus silvestris* are the only other species known to me to lack subspecific differentiation from the European.

*Camisia spinifer*, in life, is very grimy, the dorsal bristles being so intersmeared as to give the dorsum the appearance of a rectangular basket, the bristles being the withes from which the basket is woven. My wife and I always refer to it as "The Basket Nothrus."

#### Genus BELBA (14a, p. 611)

Resembling *Damaeus* but with tectopodia II not developed laterad of insertion of legs I, thus without auricles between legs I and II.

TYPE: *Notaspis corynopus* (14, p. 89, Pl. 4, Fig. 2).

#### *Belba olitor* sp. nov.

Body pulverulent; legs moniliform; cephaloprothorax nearly as wide as abdomen; pseudostigmatic organs very long, flagelliform; lamellar bristles similar to rostral, inserted just above them; exopseudostigmal bristles and interlamellar bristles fairly long, flagelliform, the latter inserted quite close to pseudostigmata; posterior edge of cephaloprothorax with cornicles; notogaster semiglobular, with eighteen rather stout, black, slightly curved bristles forming a crescent of nine bristles on each side, the anterior pair inserted rather close together, the fifth pair inserted on longitudinal plane passing slightly mesad of the fourth and sixth, the ninth pair much more slender, elongate, flagelliform, on posterior margin two additional pairs of slender flagelliform bristles, subequally spaced laterad of ninth pair, spines (of anterior edge) long, curved, slender; genital and anal apertures subequal, separated by a narrow arm of ventral plate; tibia, genua, and femora IV each with a fairly long flagelliform bristle.

COTYPES: Eight specimens from twenty-year old-field of *Andropogon* and twelve-year-old pines, Cook property, Avers Creek Township, Buncombe Co., N. C.; taken February 19, 1935, slide 34F25.2-4.

This species is usually found with nymphal notogasters piled on its back. These skins are net-reticulate and have longer bristles than the adults.

**Gymnodamaeus quadricaudiculus** sp. nov.

Resembles *G. austriacus* (30, p. 334, Figs. 17-19) in the caudal appendage of the notogaster but in the American species the notogaster terminates in four, small, circular nubbins each bearing a stout, curved bristle; pseudostigmatic organs slenderly clavate, fairly long, the head studded with a plush of spikes; notogaster sculptured with an oval ridge from which there radiates six spurs or rays, one extending anteriorly, one posteriorly, and two laterad (each side); dimensions: length of body 0.4 mm.; breadth of notogaster 0.23 mm., length of notogaster 0.28 mm.

COTYPES: Fifty to sixty specimens from *Andropogon* sod, Glen Bald, Bent Creek Experimental Forest, Buncombe Co., N. C.; taken April 17, 1925, slides 34F31n1 to -n3.

Genus **Oppiella** gen. nov.

CHARACTERS: Differs from *Oppia* in that the notogaster is moderately arched, often with anterior band more or less raised as a ridge, bearing eighteen bristles, often with an additional pair on anterior peripheral band; sides of thorax above legs II and III usually smooth or with a few low ridges; cephaloprothorax often with conspicuous knobs or/and ridges; tectopodia II variously developed.

TYPE: *Dameosoma corrugatum* (5, p. 273; 24, p. 62, Pl. 4, Fig. 23).

In a recent paper (19) I recorded the type of *Oppia* as having pseudostigmata distant from anterior edge of notogaster. Since having written this statement I have secured specimens of *Oppia nitens* from the type locality and type habitat; under bushes in gardens, Regensburg, and find that the pseudostigmata are close to the anterior edge of the notogaster. Thus *Dameosoma* is a synonym of *Oppia*. *Dameosoma ultraciliata* (19, p. 19, Figs. 16-22) and *D. alces* (19, p. 23, Figs. 154-158) thus become *Oppia ultraciliata* comb. nov. and *Oppia alces* comb. nov. respectively. In the same paper *Phauloppia bryani* should be *Eporibatula bryani* comb. nov.

**Oppiella corrugata** comb. nov.

This species has recently been referred to as *Oppia neerlandica* (29, p. 128, Fig. 132). I am unable to see any relation between Oudemans' figure of his



*Eremaeus neerlandicus* (23, p. 168, Fig. 4) and that by Paoli (24, Pl. 4, Fig. 23) and by Warburton and Pearce (28, p. 567, Pl. 20, Fig. 2). especially as I have found Oudemans' figures to be quite accurate. This species is represented in the eastern United States by the following forms:

***Oppiella corrugata apicalis* subsp. nov.**

(Figures 3-7)

As the species but sides of ridge along anterior edge of notogaster more nearly parallel and the bristle inserted at posterior bend of the ridge (Figure 3). For contrast I have included a figure of this area from specimens coming from Regensburg (Figure 1). The position of the other notogastral bristles is identical with the Regensburg specimens. They are figured as quite differently situated by Paoli for Berlese's Florentine types. Moreover, the anterolateral projection of the notogaster (shoulder spur) is longer, more extended while it is short and blunt in Regensburg specimens. Size: large for the genus, but quite variable.

COTYPES: Thirty-one specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F120p3.

Nine specimens from Great Falls, Va.; taken May 19, 1914, by Nathan Banks, slides 26B104 and -b, are intermediate between this and the next form.

***Oppiella corrugata squarrosa* subsp. nov.**

(Figure 2)

As the species but sides of ridge along anterior edge of notogaster quite parallel, forming a right angle at both anterior and posterior ends though the bristle is inserted anterior of the posterior bend of the ridge (figure 2); other notogastral bristles as in the above; shoulder spur pointed, much as figured by Paoli for the Italian race (24, Pl. 4, Fig. 23); lamellæ often with strongly developed, fine, slender, cross-ridges; lamellar bristles (in heavily sclerotized individuals) inserted on a disclike expansion of distal end of lamellæ.

MATERIAL EXAMINED: Three specimens from decaying vegetation scraped from north side of *Carex stricta* tussock, upland swamp, East Village, Monroe, Conn.; taken August 7, 1925, slide 2513n1. Five specimens from dead, overhanging leaves, east side of tussock, same locality; taken August 10, 1925, slide 2514n3. One hundred five specimens from clump of sphagnum near above tussocks; taken August 18, 1925, slides 2520n2, 2521n7, -n8, -n9, 2522n5. The sample was sun dried, beginning

at 9 A. M. The container was emptied at 11:30, 4, and 6 P. M. yielding 5, 77 and 23 specimens respectively. One specimen from core cut from top of a *C. stricta* tussock, same locality; taken August 22, 1925, slide 2525n1. Nineteen specimens from decaying vegetation scraped from sides of a *C. stricta* tussock from open marsh (recently cut over), stream valley, northeast of East Village; taken August 28, 1925, slide 2533n2. Three specimens from old, decaying, wet grass from foot of old haystack on hillside, beyond above marsh; taken September 1, 1925, slide 2534n1. Sixty-two specimens from dead leaves in woods, edge of above upland swamp; taken September 9, 1925, slide 2538n1. Eight specimens from hemlock leaf mould, from hill above state road, gorge, Sandy Hook, Conn.; taken June 24, 1926, slide 2913n1. Six specimens from moss on and scrapings from old log, and leaf mould, below state road, gorge, Sandy Hook, Conn.; taken June 25, 1926, slide 2614n1. Fifteen specimens from leaf mould, old hemlock grove (with *Polytrichum*, *Carpinus*, and *Fagus*), west slope of Miamus Ravine, N. Y.-Conn.; taken in April, slides 26n1 and -h1.

One specimen from decaying leaves at base of clump of marsh sedge, Cliff Island, Casco Bay, Me.; taken September 14, 1925, slide 2539n3. Twenty-one specimens from sphagnum of cranberry bog, same locality; taken September 17, 1925, slides 2543n1, -n6, 2544n1, -n2, -n3. These specimens from the Maine coast have the ridge of anterior edge of notogaster less square than in Connecticut specimens but the shoulder spur is well developed.

One specimen from under a stone, South Salem, Ohio; taken May 1, 1924, (no. 212 and 213), slide 32M102 (Miller coll.).

**HABITAT:** Quite ubiquitous on decaying vegetation. Although not recovered from several moss samples, it seems to be common in sphagnum! This is the commonest species of the genus with general distribution, that is it has the highest frequency.

***Oppiella foliosa* sp. nov.**

(Figures 9-12)

**DIAGNOSTIC CHARACTERS:** Bristles short, broad, clavate, blunt (figures 9 and 12); cephaloprothorax with raised ridges, simulating lamellæ and trans-lamella, and others; notogaster with a pair of shoulder spurs and their

bristle; pseudostigmatic organ head stout, directed mesad; posterior end of abdomen strongly tapering.

DESCRIPTION: Size medium; total length 0.23 mm., breadth 0.115 mm.; color reddish brown; rostrum broad, with a pair of minute apicules each side of median plane; rostral bristles bent toward each other (figure 9); posterior edge of cephaloprothorax more densely sclerotized to base of pseudostigmata, sides of cephaloprothorax with a more densely sclerotized ridge running from base of pseudostigmata forward to transverse plane of apodemata I, narrowing and turning mesad (figure 9); lamellar and translamellar bands distinct on lateral and anterior edges only; a broad, distinct band (each side) passing from lateral ends of translamellar band anteriad nearly to insertions of rostral bristles; lamellar bristles inserted posteriad of base of these translamellorostral bands; interlamellar bristles inserted on transverse plane passing anteriad of anterior edge of pseudostigmata, on a very slender ridge which runs from slightly anteriad of insertion to posterior band; pseudostigmata distant from notogaster; pseudostigmatic organ pedicel strongly bent, head broad, either studded with short, close-set bristles clotted with foreign matter or having that appearance (figures 10); apodemata III broad, very conspicuous.

Notogaster broadly ovate, anterior end pointed; posterior end somewhat mammilate, sculptured with what has the appearance of fine, pale, irregularly longitudinal lines (figure 9, anterior area); bearing the usual eighteen bristles but in regular transverse rows (which I take to represent the primitive condition); the bristles are quite flat (figure 9, bristles d2), and somewhat veined (figure 12), except the posterior pair e1 which seem more clavate and shorter; spur bristles stout, pointed, barbed (figure 11). The spur bristle, which probably represents the true a1 or a2, is often of a different form than the other notogastral bristles.

Anal aperture close to posterior edge of plate; covers with bristles close to median edge; postanal bristles behind center of cover; pseudofissuræ well developed, lateral postanal bristles foliose, inserted anterolaterad of pseudofissura, preanal bristles slender, far anteriad of anal aperture, thus in this genus these last two bristles have migrated anteriad while in the pterogasterine genera they have migrated posteriad. Due to this great diversity in position my nomenclature becomes ambiguous and I will hereafter use that of Grandjean (13, p. 57) which is:

paramesal	ag1 (agenital)
preanal or paranal	ad1 (adanal)
lateral postanal	ad2
mesal postanal	ad3

This system has the additional advantage of being more concise, and there seems to be no question about the identity of these bristles throughout the Oribatidæ or of their homology.

Genital aperture small, anterior edge strongly angled; the four cover bristles widely segregated in two pairs; parasterna III-IV with two foliose

bristles, the lateral of III (on a more densely sclerotized band) and the mesal of IV inserted on its usual spur; sternum broad between apodemata I and camerostome, narrow posteriad (figure 9); parasterna I with lateral bristle foliose; apodemata I short.

HABITAT: Soil samples, Asheville basin.

COTYPES: Thirteen specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F13aOp3.

*Oppiella stipularis* sp. nov.

(Figures 13 and 14)

DIAGNOSTIC CHARACTERS: Bristles somewhat broad, tapering to a point, that is, resembling slender stipules (figure 13); cephaloprothorax with ridges as in *O. foliosa* but without translamellorostral pair; notogaster suboval; shoulder spur bristle minute; pseudostigmatic organ head pointed, bristled in two rows (figures 13 and 14).

DESCRIPTION: Size medium, total length 0.246 mm., breadth 0.115 mm.; color pale; shape slender; closely related to *O. foliosa* but a linear as to shape of body and bristles; rostrum broad; posterior band of cephaloprothorax not developed; lamellæ and translamellæ more definite; lateral bands more lateral (figure 13); pseudostigmata closer to notogaster; interlamellar bristle ridge extending further forward; lamellar bristles inserted on end of lamellæ.

Notogaster more elongate, anterior end truncate; bristles with a raised median ridge (figure 13, bristles d2), arranged in more strongly curved rows; a pseudofissura anterior to bristles b2 quite distinct, long; anal aperture extending laterad nearly to edge of ventral plate; anal pseudofissuræ shorter, at center of sides of aperture; bristles ad3 close to posterior edge of ventral plate, ad1 near edge of ventral plate; genital cover bristles 2 nearly posterior to bristles 1; sternum not as broad as in *O. foliosa*; apodemata I longer.

COTYPES: Three specimens from epigeous moss between Andropogon stools; closely browsed Andropogon pasture between wooded ridges, two miles southwest of Bent Creek on Asheville-Brevard road; slide 34F130p1.

It is not at present possible to state if this is a moss or a soil species.

Genus SUCTOBELBA (24, p. 72)

Oppias with mouth parts attenuated; mandibular chelae fine and slender; edge of camerostome variously modified but chiefly developed ventrad and divided by one or more incisions to form lobes or lacinia; lamellar bristles springing from a prominently



raised knob just anterior to plane of pseudostigmata; this lamellar knob appears triangular in dorsal aspect.

TYPE: *Suctobelba trigona* (Michael) Paoli (24, p. 74, Pl. 4, Fig. 31; Pl. 5, Fig. 50).

Several closely related American species may be segregated in the following genus:

Genus *Suctobelbella* gen. nov.

Suctobelbas with two pairs of spurs projecting from anterior edge of notogaster out over base of cephaloprothorax; anterior edge of notogaster between mesal spurs indistinct; rostral bristles usually ciliate-pectinate; notogastral bristles eighteen; bristles ag1 much nearer edge of ventral plate than to median plane; acetabulæ III projecting laterad of notogaster as an oblong lobe bearing a small colorless nubbin on anterior face.

Type: *Suctobelbella serratirostrum* sp. nov.

A study of the various locations of the notogastral bristles leads me to the conclusion that, at least in this genus, it is the five anterior bristles which are most restless. Referring to bristles of figure 8 as the typical, primitive condition, and disregarding the spur bristle (which may be a1 or a2), I regard the anteromesal pair of bristles as a1, the bristle posterolaterad of a1 as a2, the bristle posterior to a1 as b1, and that posterior to b1 as b2 which has shifted into the mesal series from its lateral position. In the genus *Suctobelbella*, bristles c2 are actively in the process of making this same change of position as will be noticed in the case of the following five species.

*Suctobelbella serratirostrum* sp. nov.

(Figures 16 to 20)

DIAGNOSTIC CHARACTERS: Edge of camerostome cut by two (or three) incisions to form two or three lacinia (figure 17), pseudostigmatic organs clavate, bent, head ovate, distally attenuate, directed anteromesad, smooth, or with a few minute bristles, or the bristles irregularly arranged three or four abreast across the head, thus forming a brushlike structure (figures 16 and 20); notogastral bristles fairly long, fine, overlapping, a2 much closer to a1 than to b1, c2 only slightly more remote than b1, or b2, which are nearly in the same longitudinal plane (figure 16); ad2 on transverse plane passing through or slightly posteriad of anterior edge of anal aperture.

DESCRIPTION: Size medium (for the genus): length 0.2 to 0.21 mm., breadth 0.1 to 0.11 mm.; rostrum broad, not sharply demarked; rostral bristles standing out laterad as a grand moustachio; lacinia plainly visible in dorsal aspect

(figure 16), for shape of this area in anterodorsal aspect see figure 19; in posteroventral or anterodorsal aspects the lacinia seem to converge (figure 18); dorsal face of cephaloprothorax with the usual median, scallop-edged band and lateral bands enclosing a thinner area (figure 16); interpseudostigmatic ridges resembling an old English letter i, the interlamellar bristle inserted on the anterior end; behind the pseudostigmata a more densely sclerotized ridge with a posterior lobe passing under the shoulder spur.

Notogaster broadly oval, posterior edge cut away (lower half of figure 16); spurs subequal; bristles a1 more remote than lateral spurs! Posterior edge of anal aperture strongly angled; sides strongly converging (anteriorly); anterior pair of cover bristles much more remote than posterior pair; bristles ad3 slightly more remote than breadth of anal aperture, nearly on same transverse plane as posterior cover bristles (figure 16); ad2 midway between edge of ventral plate and anal aperture; anterior edge of genital aperture gently curved; cover bristles 2 and 3 not very distant, the four bristles forming a very gentle curve; sternum anterior to genital aperture quite broad; apodeme II-III interrupted.

The smaller individuals have fewer bristles on the pseudostigmatic organ head. The appearance of the edge of the camerostome varies much according to angle at which it is seen.

COTYPES: One hundred and fifty-four specimens from *Andropogon* litter of a twenty year old-field grown to ten year old pines, Cook property, Avers Creek Township on Asheville-Brevard road, N. C.; taken February 25th, 1935, slides 34F25.3-5, -6 and -8. Large size from types.

***Suctobelbella frothinghami* sp. nov.**

(Figures 23 to 25)

DIAGNOSTIC CHARACTERS: Rostrum extended anterolaterad as right angled corners (figure 23); this angle is formed by the centering of the distal end of the three lacinia of the edge of the camerostome at a common point; pseudostigmatic organ pedicel only slightly if at all bent below head, head oval to ovate, smooth, much shorter than pedicel (figures 23 and 24); notogastral bristles quite long (figure 23), bristles a2 on transverse plane passing nearer b1 than a1, c2 more remote than c1.

DESCRIPTION: Size large (for the genus, total length 0.246 mm., breadth 0.135 mm.; cephaloprothorax (figure 23) typical for the group except shape of rostrum; in lateral aspect (figure 25) edge of camerostome is seen to be produced ventrad as a point, above which are the reduced incisions, and fused lacinia, dorsoposteriad of which is a large thinly sclerotized reniform area; dorsal face of cephaloprothorax with the usual median, and lateral scallop-edged bands enclosing a thinner area (figure 23); pseudostigmata with a large posterior lobe which extends under the shoulder spur; interpseudostigmatic ridges bilobed, with well-developed connective which passes over

base of lamellar knob, interlamellar bristles inserted on anterior of the two lobes.

Notogaster, in dorsal aspect, nearly circular; median spurs broad, blunt; acetabulæ III very broad; notogastral bristles widely overlapping when depressed, bristles a1 posteriad of lateral spur, not distant from it, a2 nearer b1 than to a1, c2 more remote than a1, b1, or b2 which are in the same longitudinal plane (figure 23). Anal pseudofissuræ long; bristles ad2 inserted on transverse plane posterior to anterior edge of anal aperture, and near edge of ventral plate; genital covers with bristles 3 more remote than 2; parasterna III-IV with median bristle not as distant from the posterior bristle as greatest width of a genital cover.

**HABITAT:** Typically a species of deciduous woodland litter.

**COTYPES:** Thirty-seven specimens from litter of isolated short-leaf pine stand, two miles southwest of Bent Creek, on Asheville-Brevard road, N. C.; slide 34F10.20p1.

Named for Earl Hazeltine Frothingham, Senior Silviculturist at the Appalachian Forest Experiment Station.

***Suctobelbella longicuspis* sp. nov.**

(Figures 21 and 22)

Similar to *S. frothinghami* but smaller (0.2 by 0.1 mm.); anterolateral corner of edge of camerostome drawn out into a fairly long lacinia, curved anteriorly (figure 21), behind which are three subequal, much shorter lacinia, these lacinia separated by slender incisions, rounded at dorsal end, the proximal tooth merging into body of camerostome edge (figure 21); in dorsal aspect the long curved anterior lacinia is seen projecting each side of rostrum; pseudostigmatic organ head directed mesad, obliquely truncate (figure 22), side tapering proximad, not as elongately oval as in *S. frothinghami*; notogastral bristles a2 closer to a1 than to b1, bristles c2 slightly more remote than a1, b1, and b2.

Ventral aspect quite similar to *S. frothinghami*.

**COTYPES:** Twenty-four specimens with *S. frothinghami* but preferring the lowest part of the litter layer; slide 34F10.30p2.

***Suctobelbella laxtoni* sp. nov.**

(Figures 28 to 30)

Color usually quite pale; size small, length 0.17 to 0.19 mm., breadth 0.09 to 0.1 mm.; abdomen high and broad; rostrum somewhat compressed so as to be narrower than anterior end of cephaloprothorax; edge of camerostome with three rather short and broad lacinia (figure 30); interpseudostigmatic ridges open mesad, forming a broad figure (figure 28); pseudostigmatic organ head compressed, dorsal edge with two or three rows of short, spiny

"bristles" (figures 28 and 29); notogastral bristles short, stout, stiff (not flexuous), a1 posteriad of mesal spur, a2 on transverse plane passing through b1 or only slightly anteriad, bristles c2 much more remote than b2; anal cover bristles both near lateral edge of cover.

**HABITAT:** Chiefly soil and lowest litter layer.

**COTYPES:** One hundred and seven specimens from *Andropogon* litter of a twenty year old-field grown to ten year old pines, Cook property, Avers Creek Township on Asheville-Brevard road, N. C.; taken February 25, 1935, slide 34F25.3-5, -6 and -8. The larger size is from the types.

Named for Miss Josephine Laxton of the Appalachian Forest Experiment Station.

***Suctobelbella hurshi* sp. nov.**

(Figures 26 and 27)

**DIAGNOSTIC CHARACTERS:** Rostrum rounded, compressed, rostral bristles standing out at right angles; edge of camerostome with but one incision, thus forming only two rounded lobes (figure 27); pseudostigmatic organs quite similar to those of *Oppiella corrugata*, that is with fairly long cilia in one row, but with pedicel bent so as to direct head across prothorax; notogaster ovate, bristles medium long (figure 26), a1 more remote than lateral spurs, a2 on transverse plane passing near b1, c2 slightly more approximate than c1, thus having taken its place in the mesal row.

**DESCRIPTION:** Size medium, length 0.2 mm., breadth 0.1 mm.; cephaloprothorax quite typical; rostrum, in lateral aspect, low, with rounded dorsal outline; dorsal aspect of prothorax similar to that of *S. (S.) frothinghami* except that the interpseudostigmatic ridges are shaped roughly like a capital J without distinct crosspiece, the interlamellar bristle being inserted in the head (figure 26); notogastral spurs somewhat closer together; bristle a2 much nearer b1 than to a1 (figure 26); genital cover bristles 3 more approximate than 4. Easily recognized by the compression at base of rostrum and its peculiar shape.

**HABITAT:** Evidently a species of pasture sod.

**COTYPES:** Forty-two specimens from closely browsed *Andropogon* pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F120p4.

Named for Dr. Charles R. Hursh, Ecologist of the Appalachian Forest Experiment Station.

***Eremulus cingulatus* sp. nov.**

Differs from *E. modestus* (6, p. 10; 7, Pl. 21, Fig. 79) in that the lamellar ridges are more remote, spanning the interlamellar bristles; there are no



pocks at base of cephaloprothorax; bristles a1, a2, b2 are well developed; the posterior edge of the post-thorax is indicated by a wavy line lined with areoles, the whole area being often raised (in lateral aspect) above the abdomen proper. Foreign matter coating the animal often hides this posterior edge of the post-thorax. Dimensions: length 0.36 mm.; breadth 0.19 mm.

COTYPES: Nine specimens from closely browsed *Andropogon* pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11E.

***Eremulus pectinatus* sp. nov.**

(Figure 8)

Differs from all described species by its strongly pectinate pseudostigmatic organs (figure 8). Dimensions: Length 0.25 mm., breadth 0.12 mm.

COTYPES: Fourteen specimens from surface soil and weeds of plowed land abandoned five years, Bent Creek area, ten miles southwest of Asheville, N. C.; slide 34F20.5.

***Carabodes falcatus* sp. nov.**

(Figure 15)

Abdomen margined, shouldered, coarsely areolated, with translucent, clavate, appressed notogastral bristles; genital aperture distant from anal the length of genital; pseudostigmatic organs falcate, head pointed, linearly coarsely scabrate (figure 15); length 0.365 to 0.53 mm., breadth 0.2 to 0.3 mm.

COTYPES: Thirty-eight specimens from soil sample (including surface crumbles, that is the H layer) under eighty year old pine-oak woodland, Bent Creek Experimental Forest, Asheville basin, N. C.; slide 34F21.5.

***Liacarus spiniger* sp. nov.**

Body oval, quite variable in size, length 0.49 to 0.68 mm., breadth 0.27 to 0.39 mm.; pseudostigmatic organs slenderly clavate, head subequal to pedicel, bearing a stout, burred spine nearly as long as head; distal end of lamellæ with corners drawn out as cats' ears, the mesal the longer; lamellar bristles stout, stiff, barbed, inserted on a slight swelling between the lamellar ears; interlamellar area produced as a cone; the two shoulder bristles shorter than spine of pseudostigmatic organs; notogastral bristles as long as diameter of tarsi and tibiæ I and II.

COTYPES: Twenty-nine specimens from same sample as the preceding; slide 34F21-27.

Closely related to *L. coracinus* (29, p. 152, fig. 214) but lamellæ with short blunt ears and shoulder bristles much longer.

***Tectocephus velatus* 20, p. 189, Pl. 6**

This species is represented by a subspecies in America. I say subspecies because the insertions of the rudimentary bristles are in the same position as in specimens from Regensburg (Bavaria).

In 1904 (4, p. 252) *T. minor* from Florence, Italy, was described as differing from the Italian *T. velatus* (3, fasc. 77/2) in having finer, more crowded granules, a less clavate pseudostigmatic organ and in being smaller (290 versus 350 microns long). The figures (9, Pl. 2, Fig. 31) show *T. minor* to have the same lamellæ as the Italian *T. velatus*. The pseudostigmatic organ head looks less clavate in some aspects or positions because the head is compressed not circular in cross-section. Furthermore this species is somewhat variable. Thus I do not regard *T. minor* as specifically distinct from *T. velatus*.

*T. minor expansus* (9, p. 422, Pl. 2, Fig. 32) is described as broader and shorter, cephaloprothorax longer and narrower, pseudostigmatic organs nearly twice as long, angle of pteromorphæ produced as a rounded angle, granules less dense than in the species. Type locality: North America. The figure (9, Pl. 2, Fig. 32) shows the distal ends of the lamellæ to be wider than in the species (*T. minor*) much resembling *T. v. sarekensis* (27, p. 517, Figs. 290-293). This Scandinavian form however has very different pteromorphæ (27, Fig. 292). Thus the American form may be known as:

***Tectocephus velatus expansus* comb. nov.**

Differs from the species in having distal end of lamellæ broad, the bristle inserted on lateral edge; genital cover bristles 2, 3, and 4 (the three posterior bristles) subequally spaced while in Regensburg specimens bristles 3 and 4 are more widely spaced than 2 and 3. This is a normal condition, exceptions being present on both sides of the Atlantic.

In eastern America I find two marked forms which I will refer to as impressed and smooth. The impressed forms have a series of four fair sized impressions along each side of the notogaster. These are lacking in the smooth form. The impressions are plainly visible under magnification of twelve in dry material but

are invisible in mounted or alcoholic specimens. These two forms are further characterized by the following differences. The impressed have the pseudostigmatic organ head longer, more slender, the surface pebbled to nobby, the pedicel longer, sharply bent; notogastral bristles finer, pale, indistinct; notogastral pseudofissura distinct; surface without clean-cut granules but with flattened, smudgy, more widely spaced granules. This I take to be the true *T. v. expansus* because of the long pseudostigmatic organ and the more widely spaced granules. The unimpressed form has pseudostigmatic organ head shorter, broader, with surface strongly spiny, the pedicel shorter, nearly straight to gently curved; the notogastral bristles are larger, stouter, dark; the pseudofissura is indistinct; the surface has prominent, clean-cut granules.

These differences are not due to sex as individuals of both forms bear a maximum of two large eggs. Furthermore the two forms are not sharply segregated as to habitat, though one form or the other usually predominates. I therefore regard them as representing a dimorphic subspecies. I have not yet seen an American form with the pointed lamellæ of *T. velatus* as figured by Michael (21, p. 313, Pl. 21, Figs. 9-15). Specimens from one lot have two pairs of impressions on the anterior half of the notogaster, thus being quite intermediate in this characteristic.

***Scheloribates muiricius* sp. nov.**

Similar to *Sch. lanceoliger* (6, p. 2) but pseudostigmatic organs resembling those of *Sch. muiri* (19, p. 53, pl. 8, figs. 69-79), adalar bristle close behind its porose area which is barred; posteriormost bristles of notogaster more remote, more remote than pair anterior to them, the porose area laterad; middle pair of sternal bristles at sides of slender sternum; length 0.4 to 0.44 mm.

COTYPES: Thirteen specimens from litter of isolated short-leaf pine stand, two miles southwest of Bent Creek, Asheville-Brevard road, N. C.; slide 34F10.2Sch.

This species is named after John Muir, seer of the Rockies. In general appearance, especially the pseudostigmatic organs, it resembles *Sch. muiri* which is named after the late Frederick Muir, formerly chief entomologist of the Experiment Station of the Hawaiian Sugar Planter's Association.

***Xylobates oblonga robustior* subsp. nov.**

Pseudostigmatic organ head slender, the fringe formed of spinelike projections spaced half their length from each other; the number of elements to the fringe varies considerably either on the pedicel or on the head, there occasionally being some on the opposite edge; total length 0.47 to 0.51 mm., breadth 0.29 to 0.32 mm.

COTYPES: Thirty-seven specimens from upper inch of soil, eighty year old pine-oak woodland, Bent Creek Experimental Forest, northeast of laboratory buildings, Asheville basin, N. C.; slide no. 34F21-1.

*Oribata oblonga* (12, p. 73, Pl. 11, Fig. 37) was described from Columbia, Missouri. A year earlier *Protoribates capucinus* (6, p. 2) was described from Italy and Columbia, Missouri. As most American species found also in Italy differ at least subspecifically, *X. capucinus* must be restricted to Italy, Berlese not recognizing the subspecific difference. With this understanding I will use *X. oblonga* as representing the American species. The length of the Italian individual is given as 0.42 (average or maximum?, probably the latter); the length of *X. oblonga* is given as 0.44 (average or maximum?).

***Peloribates curtipilus* sp. nov.**

Surface smooth; bristles short, nearly straight, stout, burred; pseudostigmatic organs clavate, with short pedicel, head finely barbed in about five rows; length 0.348 to 0.4 mm., breadth 0.238 to 0.26 mm.

COTYPES: Eleven specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11.

**Genus *Propelops* gen. nov.**

Resembling *Pelops* in arrangement of notogastral bristles and porose areas, in development of pteromorphæ, lamellæ, pseudostigmatic organs, and tectopodia I and II, but differing in having normal mouthparts and unexpanded interlamellar bristles.

TYPE: *Propelops pinicus* sp. nov.

***Propelops pinicus* sp. nov.**

Pseudostigmatic organs porect, clavate, slightly burred; interlamellar bristles very long, stout, slightly burred, extending anteriorly and ventrad to end of rostrum; lamellar bristles inserted on under face of lamellæ, sharply



bent, extending mediad beyond rostrum; rostrum covered with rounded, rivet-headlike knobs; rostral bristles short, clavate, fimbriate along edge of head, inserted well back on lower edge of genæ; lamellæ very broad, with slender translamella, nodose (like rostrum); pteromorphæ with anterior edge above tectopodia II undulate, over cephaloprothorax gently convex; notogastral bristles short, stiff, smooth, except a closely spaced posterior pair which are clavate.

COTYPES: Twelve specimens from short-leaf pine litter of isolated stand two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F10.2P2.

***Pelops brevipilus* sp. nov.**

“Eyed”; anterior edge of notogaster triundulate; interlamellar area deeply “excised”; rostrum compressed, slender; lamellar bristles large clavate, blunt; pseudostigmatic organs gently curved, half length of lamellar bristles, slenderly clavate; notogastral bristles short, inconspicuous, posterior edge of notogaster impressed along median line; length 0.34 mm., breadth 0.26 mm.

COTYPES: Thirty specimens from closely browsed *Andropogon* pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11P.

ANALYSIS OF THE FOREST FLOOR ARTHROPODS

Ivar Trägårdh's sensationally written paper (26) concerning my “Evaluation of the forest floor population” (19) cannot be considered as a contribution to scientific (that is impartial and unbiased) literature. I wish, however, to set forth certain facts which he did not trouble himself to secure. While in China I made two attempts to secure his paper of 1929 (25) but he failed to aid me. My paper was written the summer of 1932, and it was not until after the paper had gone to press that I actually saw a copy of his paper while at Ithaca. As it is an exception to those papers I reviewed, I see no reason why I should have included it, especially as it was a brief preliminary (?) paper.

In 1919 I first became interested in determining the exact habitats of Oribatid mites, and have been collecting forest floor material with that idea, carefully separating the various elements of the forest floor. This work I continued while in China. As Trägårdh knows, the analysis of such material is a long and tedious process—especially when each subfamily and even each

species has to be entirely revised (locally) and restudied before specific determinations can be made. A careful study of my habitat data (15, p. 267; 17, p. 260) might have revealed this type of collecting. In brief I had not only gone over the European literature with care but had been carrying on fractional, analytical collecting of forest floor material for over ten years before writing as I did.

Trägårdh's own paper of 1929 corroborates my suggestions for future procedure. I have made certain practical suggestions. Trägårdh objects on the ground that it is too difficult (top of page 56). It is the scientist's duty to find a way, and he will. I placed the emphasis on qualitative as opposed to quantitative analysis. This is generally admitted to be a preferable objective. There is certainly no harm in reorienting any future American work along this line. Thus I do not see what axe Trägårdh has to grind except that I omitted considering his own brief contribution.

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For further details on the above references see my "Annotated Bibliography of the Moss Mites (Oribatoidea, Acarina)" and its appendices.

## PLATE 26

*Oppiella corrugata* (from Regensburg)

- Figure 1. Midthoracic region, showing ridge of anterior edge of notogaster; ratio  $\times 330$ .

*Oppiella corrugata squarrosa subsp. nov.*

- Figure 2. Same aspect; ratio  $\times 330$ .

*Oppiella corrugata apicalis subsp. nov.*

- Figure 3. Same aspect; ratio  $\times 330$ .

- Figure 4. Lateral aspect of prothoracic ridges and pseudostigmatic organ; ratio  $\times 330$ .

- Figures 5 & 7. Pseudostigmatic organ head, anterior aspect; ratio  $\times 440$ .

- Figure 6. Same, dorsal aspect to left of numeral, anterolateral aspect to right; ratio  $\times 440$ .

*Eremulus pectinatus sp. nov.*

- Figure 8. Pseudostigmatic organs; ratio  $\times 440$ .

*Oppiella foliosa sp. nov.*

- Figure 9. Dorso/ventral aspects, legs and mouth parts omitted; ratio  $\times 330$ .

- Figure 10. Pseudostigmatic organ, lateral aspect; the one to left of numeral partly cleaned off; ratio  $\times 440$ .

- Figure 11. Shoulder bristle; free hand.

- Figure 12. Notogastral bristle, veining indicated; free hand.

*Oppiella stipularis sp. nov.*

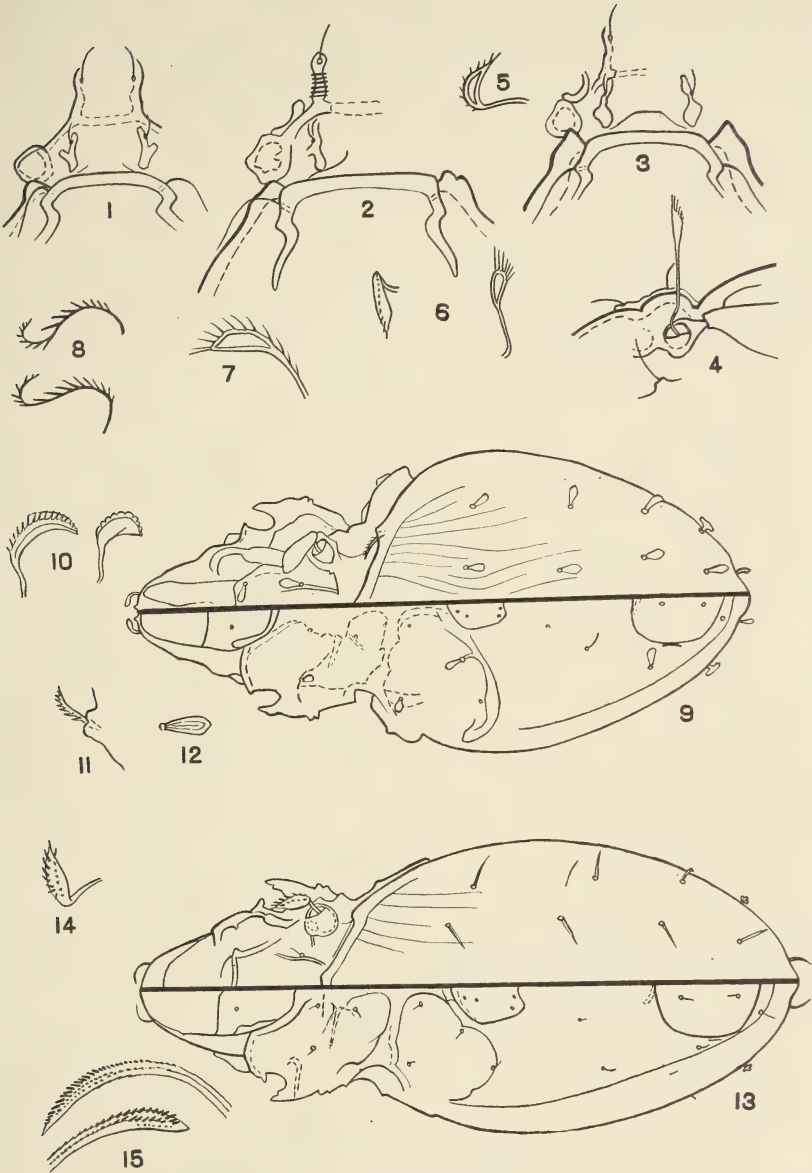
- Figure 13. Dorso/ventral aspects, legs and mouth parts omitted; ratio  $\times 330$ .

- Figure 14. Pseudostigmatic organ, dorsal aspect; free hand.

*Carabodes falcatus sp. nov.*

- Figure 15. Pseudostigmatic organs; ratio  $\times 440$ .





MOSS-MITES

## PLATE 27

*Suctobelbella serratirostrum* sp. nov.

- Figure 16. Dorso/ventral aspects, legs and mouth parts omitted; ratio  $\times 330$ .  
Figure 17. Rostrum, lateral aspect; free hand.  
Figure 18. Rostrum, posteroventral aspect; free hand.  
Figure 19. Edge of camerostome, anterodorsal aspect; ratio  $\times 440$ .  
Figure 20. Pseudostigmatic organ, side view, showing the several rows of bristles; ratio  $\times 440$ .

*Suctobelbella longicuspis* sp. nov.

- Figure 21. Rostrum, dorsolateral aspect; ratio  $\times 440$ .  
Figure 22. Pseudostigmatic organs, figure to right of numeral is dorsal aspect, figure to left is somewhat lateral; free hand.

*Suctobelbella frothinghami* sp. nov.

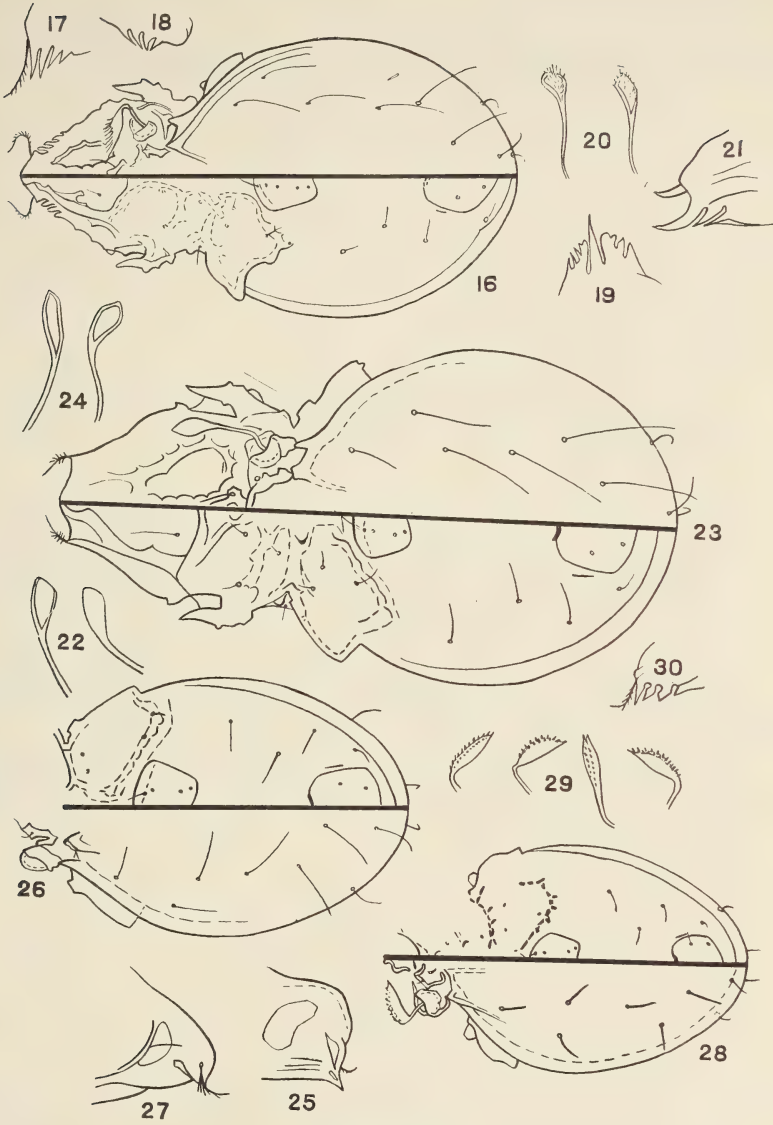
- Figure 23. Dorso/ventral aspects, legs and mouth parts omitted; ratio  $\times 330$ .  
Figure 24. Pseudostigmatic organ, slender head to left of numeral, broad head to right; ratio  $\times 440$ .  
Figure 25. Rostrum, lateral aspect; ratio  $\times 440$ .

*Suctobelbella hurshi* sp. nov.

- Figure 26. Abdomen and part of prothorax, dorso/ventral aspects; ratio  $\times 330$ .  
Figure 27. Rostrum, lateral aspect; ratio  $\times 440$ .

*Suctobelbella laxtoni* sp. nov.

- Figure 28. Abdomen and part of prothorax, dorso/ventral aspects; ratio  $\times 330$ .  
Figure 29. Pseudostigmatic organs, dorsal aspects, except figure to right of numeral which is lateral aspect; ratio  $\times 440$ .  
Figure 30. Rostrum, lateral aspect; free hand.



MOSS-MITES

## SEVENTH INTERNATIONAL CONGRESS FOR ENTOMOLOGY, BERLIN, 1938

By Resolution adopted by the Executive Committee for the International Congresses for Entomology, the

*Seventh International Congress for Entomology*  
will convene in Berlin, from August 15th to 20th, 1938.

Discussions will be held in the following sections and on the subjects indicated below:

### A. *General Entomology*:

(1) Systematism and Zoögeography. (2) Nomenclature and Bibliography. (3) Morphology, Physiology, Embryology and Genetics. (4) Oecology.

### B. *Applied Entomology*:

(1) Medical and Veterinary-medical Entomology. (2) Agriculture and Sericulture. (3) Forest Entomology. (4) Agricultural Entomology, (a) Viticulture and pomiculture. (b) Agriculture and olericulture. (c) Vermin. (5) Means and methods for fighting vermin.

The Management of the Congress will deeply appreciate the participation of numerous Representatives of Scientific and Practical Entomology in the Congress to be convened in Berlin.

All entries for participation, and all inquiries, should be addressed to the Secretary General, Professor Dr. Hering, Invalidenstrasse 43, Berlin N. 4.



## ANTHIDIINE BEES IN THE COLLECTION OF THE NATURAL HISTORY MUSEUM OF SAN DIEGO, CALIFORNIA

BY HERBERT F. SCHWARZ

For the opportunity to examine the specimens reported upon in this paper I am indebted to Dr. Clinton G. Abbott, who at the kind suggestion of Professor T. D. A. Cockerell submitted them to me. Although the material does not include any new species, the large series of some of the existing species gives opportunity to demark the range of variability that these species present. Of incidental value may also be the new locality records. Almost without exception the species reported upon were collected in California and for the most part in San Diego County. Because of this fact it has seemed appropriate to add a plate, skilfully drawn by Mr. Pierre-Noël, presenting contrasts as well as resemblances in the structure and the maculation of the clypeus of the female of certain California species of *Anthidium*. The dentition or lack of dentition of the clypeus are characters not infrequently neglected in the descriptions. Although there is sometimes great similarity between the clypeus of two species—for instance, *placitum* (Fig. F) and *edwardsii* (Fig. G)—such species may differ fundamentally in other respects. The female of *placitum*, for example, has a tooth on each side of its apical tergite while the female of *edwardsii* is devoid of such teeth. Nevertheless, comparative study of a character has its interest although not in itself conclusive as to the affinities of the insects that share that character. There is frequently variability in respect to the maculations in a given species, and not always are even the individuals of that species bilaterally symmetrical. A case of asymmetry is shown in the maculation of the clypeus of *collectum* (Fig. D).

### *Anthidium atripes* (Cresson)

(Fig. B)

California.—Laguna Mts., San Diego County, June 29, 1921, 1 ♀ and 1 ♂; Laguna, San Diego County, June 7, 1926, 3 ♂♂,

collected by W. S. Wright; Pine Valley, San Diego County, June 27, 1927, 1 ♂; without locality designation, 1 ♀.

This species, which Cresson originally described merely as a variety of *emarginatum*, although structurally as well as in its maculations it is distinct, is nevertheless much more variable than I had been led to believe from an examination of the few specimens that up to the present have been available. Cresson's type—a male—is largely covered with black hair instead of the silvery hair so characteristic of the vast majority of the males of *Anthidium*. In the present series the males all have silvery hairs greatly predominant; in most of them indeed the black hairs are traceable, if at all, only on the under side of the abdomen and on the metatarsi (especially those of the middle pair of legs), but even in these areas the pale hairs greatly outnumber the darker ones. What makes for pause in separating these insects from typical *atripes* is that similar diversity in the color of the hairs, presenting both of the extremes as well as intermediate conditions, occurs in other species (*vide* Cockerell, 1925, Proc. Cal. Acad. Sci., (4), XIV, p. 356; Schwarz, 1927, Amer. Mus. Novitates, No. 252, pp. 1-5, and Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 372-377).

Not only is there variability in respect to the color of the hairs but also with respect to the maculations. Of the five males submitted by the Natural History Museum of San Diego, four resemble the type in having either wholly black legs (as indicated in Cresson's description of *atripes*) or at most a tiny spot—easily overlooked—at the base of the fore tibiae. The fifth specimen—one of those from Laguna—has a larger maculation at the base of both the fore and the middle tibiae, a stripe at the apex of the fore tibiae supplemented by a maculation at the base of the fore metatarsi, and a splash of color near the apex of the fore femora. In all the five males the bands on the tergites are "deeply emarginate and interrupted" and in three of these males tergites 5, 6, and 7 are entirely black, showing in this respect a greater degree of melanism than the type, which has at least two dots on tergite 5 although it has tergites 6 and 7 black. However, by way of offset, the other two male specimens have the abdomen more maculated than the type. One of them—a specimen from Laguna with

black legs—has on tergite 5 two quadrate spots with a transverse line extended laterad from the apex of each of them, on tergite 6 two spots of irregular shape, on tergite 7 two spots localized on the lateral lobes. The other—likewise a specimen from Laguna with wholly black legs—agrees with the type in having two small maculations on tergite 5 and an immaculate tergite 6 but differs in having the lateral lobes of tergite 7 each with a maculation.

The two females submitted have more black hairs than the males, yet are not as dark in appearance as the female I described (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 389–390). Virtually the entire head (except for a few interspersed black hairs on the clypeus in the specimen without locality designation) and the sides of the thorax as well as the mesonotum are covered with silvery hairs. The hairs of the legs, too, are mainly pale although the metatarsi and other tarsal joints and to some extent also the tibiae, especially the middle and hind pair, have considerable dark hair. In the specimen without locality designation the hairs on tergites 5–6 and on the apex of tergite 4, as well as the ventral scopa, are black. In the female from Laguna Mts. the ventral scopa is black except for a few silvery bordering hairs at the side, but the two apical tergites, instead of black, have for the most part silvery hairs thinly interspersed with black. The two females in question agree with the female I described in having the legs immaculate, and one of them is in further agreement with that female in also having tergites 5–6 immaculate. In the other specimen tergite 6 is immaculate but tergite 5 has two faint spots. Tergites 3–4 are more fully maculated in these two females than in the female I described although their maculations are not of uniform extent, and both of them have the lateral halves of the band on tergite 1 without emargination—in one of the two specimens, however, this band has imbedded dark spots. In both of these females the axillae as well as the scutellum are maculated whereas in the accompanying males it is only the scutellum that has yellow spots.

### ***Anthidium banningense* Cockerell**

(Fig. C)

California.—Lake Tahoe, July 8, 1926, 1 ♀ and 1 ♂, collected by W. S. Wright.

These are the only two specimens in the collection from Lake Tahoe and the fact that the female accords with the specimens that I have previously interpreted as that sex of *banningense* (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 390-391) lends support to the correctness of that association.

### **Anthidium collectum** Huard

(Fig. D)

California.—Laguna, San Diego County, June 7, 1926, 1 ♂, collected by W. S. Wright; Warner's, San Diego County, Aug. 6, 1921, 1 ♂; San Diego, April 20, 1921, 1 ♀.

The last visible sternite of the male of *collectum* has like the corresponding sternite of *palliventre* a triangular emargination at the apex of its middle element, but the lateral spines of this sternite are shorter and sharper in *collectum* than in *palliventre*, while the exterior lobes of the pygidium are in *collectum* rather straight at least along their outer margin whereas in *palliventre* they are shaped somewhat like the horns of a crescent. The strong yellow stripes on the external surface of the tibiae still further differentiate the male of *collectum* from the male of *palliventre* with its black tibiae.

### **Anthidium clypeodentatum lutzi** Schwarz

(Fig. A)

California.—Warner's, San Diego County, Aug. 1, 1921, 1 ♀.

The single female here reported upon differs slightly from the original description of this variety (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 380-381). In contrast with the condition in the type of *lutzi*, the apex of the clypeus is strongly dentated medianly as well as laterally, with a total of seven clearly defined teeth. In typical *clypeodentatum* there is considerable variability in the dentition of the clypeus (see Schwarz, 1928, Canadian Entomol., LX, pp. 215-216) and it is to be presumed that there is a similar range of variability in the variety *lutzi*. There is a clearly defined carina down the middle of the clypeus in the specimen from Warner's that is sometimes only obscurely present in typical *clypeodentatum*. The black area down the middle of the clypeus is more extensive in the present specimen



than is indicated for the type, somewhat suggesting the condition in *placitum*. The specimen lacks a maculation on the mesopleura, has the hind coxæ black, and the stripes on the under side of the femora confined to the apical half. However, the variability in the maculations of Anthidiines, even when a given species is obtained from a single locality, is apt to be considerable and accordingly I place this specimen in the variety *lutzi*, with which it agrees in so many essentials.

**Anthidium fontis** Cockerell

(Fig. E)

California.—Warner's, San Diego County, July 29, 1921, and Aug. 1-6, 1921, 2 ♂♂.

**Anthidium maculosum** Cresson

(Fig. H)

California.—San Diego, July 20, 1920, 1 ♂, collected by W. S. Wright; Warner's, San Diego County, Sept. 1920, 3 ♀♀ and 6 ♂♂, collected by George H. Field; Pine Valley, Aug. 1, 1927, 1 ♀, Aug. 6-21, 1927, 3 ♀♀ and 1 ♂. Arizona.—Summerhaven, Alt. 7700 ft., Santa Catalina Mts., Aug. 12, 1934, 1 ♀, collected by Ian Moore. There are also four males without locality designation bearing the following accession numbers: 631 (two of them), 638, and 591.

The females of this series are rather constant from specimen to specimen in respect to their maculations. The males also differ relatively little. Most of them have the middle and hind metatarsi yellow externally but the fore metatarsi black; on the other hand, there are some that have yellow also on the front metatarsi, usually in such cases over the entire outer surface of the joint but in one instance only over the basal half.

**Anthidium mormonum fragariellum** (Cockerell)

California.—Laguna, San Diego County, June 16, 1926, 1 ♂, collected by W. S. Wright.

This specimen, like Cockerell's type of *fragariellum*, has "a pair of large cuneiform patches, deeply incised posteriorly" on tergite 1 of the abdomen.

**Anthidium placitum** Cresson

(Fig. F)

California.—Pine Valley, San Diego County, 2 ♀♀ and 1 ♂, Aug. 1, 1927, collected by F. W. Kelsey, and 15 ♀♀ and 18 ♂♂, Aug. 6–21, 1927.

This large series—all from a single locality and collected in the course of a single month—nevertheless shows variability in its markings. Of the males some have the scape in front fully maculated, others only partly maculated, others not at all. The maculation above the summit of the eye of the male is sometimes merely spot-like, sometimes linear and extended inward for a distance as great or greater than that which separates the maculation from the corresponding maculation above the other eye. All of the males have L-shaped stripes antero-laterally on the mesonotum, a maculation on the axillæ that is confluent with a broad stripe-like maculation bordering the posterior half of the scutellum except for a brief interruption at the middle, maculated tubercles, and a maculation anteriorly and a smaller maculation posteriorly on the tegulæ. All of the males, too, have stripes on all of the femora but of somewhat variable development, and all of them have the tibiæ and tarsi externally yellow. In seventeen of the males the propodeum is wholly black but two have yellow maculations in this region—a condition more usual in the female. Throughout the series all seven tergites bear maculations but not of altogether uniform richness, some of the males being quadrimaculate on tergite 1, others bimaculate. The degree to which the bands on the subsequent tergites are emarginate above also varies as does the degree of the fusion or separation of the two halves of the bands on tergites 4 and 5.

In the females there is also variability. I have already discussed the instability of maculation in the female of *placitum* in a previous paper (1927, Amer. Mus. Novitates, No. 252, p. 17). The differences there noted in the few specimens then available, likewise from San Diego County, are confirmed and extended in the much larger series now before me. In many of the specimens the stripe on the scape is confined to the base, in other cases it runs from base to apex, in two specimens the stripe is absent. The band of black down the middle of the otherwise yellow clypeus

is of variable width, sometimes terminates before reaching the apex, and in rare instances has almost disappeared. The stripe on the vertex is sometimes nearly continuous, at other times interrupted by a space equalling that between the lateral ocelli; in none of the females are these maculations merely spotlike as in some of the males. The thorax of the females viewed from above is maculated as is that of the males, the maculations being pretty well standardized from specimen to specimen. On the other hand, the two spots on the propodeum that in a key to the females of *Anthidium* (1927, Amer. Mus. Novitates, No. 253, p. 15) I used as a character for the separation of *placitum* are of very variable development, are faint in several of the specimens, and in three cases out of the seventeen even lacking. The legs in all the specimens are predominantly yellow, but there is some variability nevertheless in the extent of the surviving black areas on the femora and elsewhere. In only one of the specimens before me is the band on tergite 1 subdivided into four parts; in all the other cases there is merely a median division, the two halves posteriorly emarginate. The degree of fusion or separation medianly of the bands on tergites 4-5 shows variability as in the male, tergite 5 being almost invariably continuous although emarginate. It is somewhat exceptional to find the maculation on tergite 6 of the female completely subdivided into two spots although the two elements are frequently semidetached.

***Callanthidium illustre* (Cresson)**

California.—Pine Valley, San Diego County, Aug. 1, 1927, 2 ♂♂, collected by F. W. Kelsey.

***Dianthidium parvum swenki* Schwarz**

California.—Pine Valley, San Diego County, Aug. 6-21, 1927,

***Dianthidium pudicum consimile* (Ashmead)**

California.—Warner's, San Diego County, Sept. 1920, 1 ♀, 1 ♂, collected by George H. Field; Pine Valley, San Diego County, Aug. 1, 1927, 1 ♀.

The females are doubtfully assigned to *consimile*. Their maculations are in accord with those of *consimile* but the slightly curvilinear emargination between the second tooth of the mandible and

the inner angle of the mandible is more indicative of the condition usually observed in *davidsoni*. It is possible, therefore, that the females in question are slightly undermaculated representatives of *davidsoni*.

***Dianthidium ulkei davidsoni* (Cockerell)**

California.—Pine Valley, San Diego County, Aug. 6–21, 1927, 2 ♂♂.

***Anthidiellum robertsoni* (Cockerell)**

California.—Warner's, San Diego County, July 29, 1921, 1 ♀; San Diego, July 27, 1921, and Aug. 25, 1921, 2 ♂♂; Pine Valley, San Diego County, Aug. 6–21, 1927, 1 ♂.

In two of the males the inverted T-shaped figure in black on tergite 6 is imperfectly formed, one of them having a black area only in the region between the tuberculate prominences without the supporting shaft of the T. In this specimen tergites 4–5 are not four-spotted after the usual manner but are bimaculate with a semienclosed black spot apically in each of the maculations.

***Paranthidium jugatorium* variety *perpictum* (Cockerell)**

Arizona.—Summerhaven, alt. 7700 ft., Santa Catalina Mts., Aug. 18, 1934, 2 ♀♀ and 1 ♂, collected by Ian Moore.

One of the females has a virtually continuous band across the vertex and rather broader lateral face-marks than is usual in the variety *perpictum*, in these respects somewhat resembling the variety *lepidum* of the Southeast.

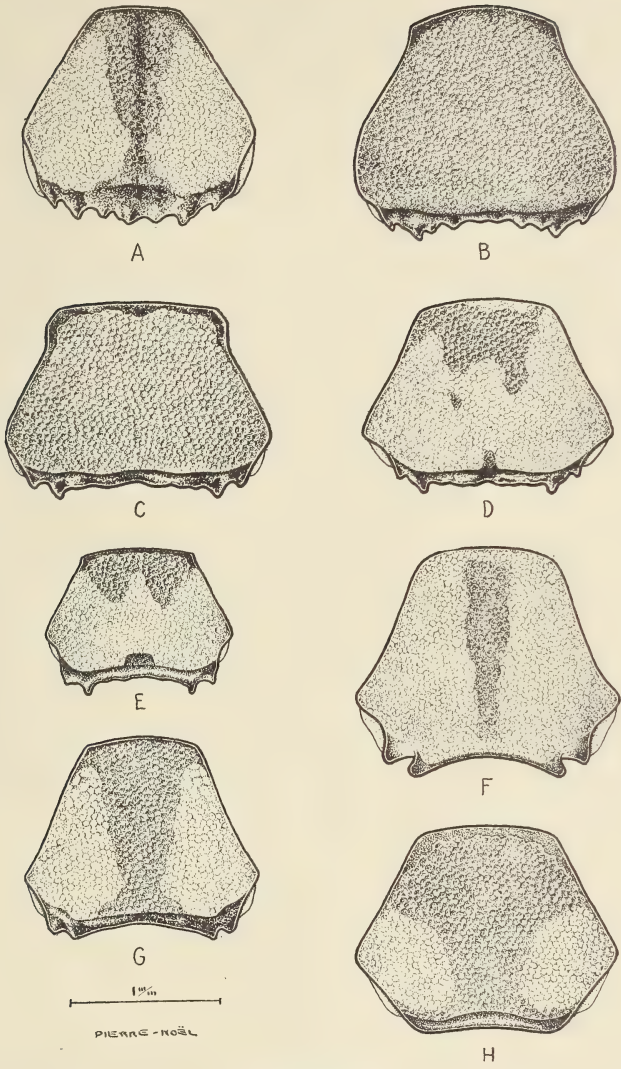
The variety *perpictum* is known to occur in New Mexico and Colorado. This is, I believe, the first record of its occurrence in Arizona.

PLATE 28

Clypeus of Female of California Species of *Anthidium*

- |   |                                       |
|---|---------------------------------------|
| A. <i>Anthidium clypeodentatum lutzii</i> Schwarz | B. <i>Anthidium atripes</i> (Cresson) |
| C. <i>Anthidium banningense</i> Cockerell         | D. <i>Anthidium collectum</i> Huard   |
| E. <i>Anthidium fontis</i> Cockerell              | F. <i>Anthidium placitum</i> Cresson  |
| G. <i>Anthidium edwardsii</i> Cresson             | H. <i>Anthidium maculosum</i> Cresson |





ANTHIDIUM

## BOOK NOTICE

*A Glossary of Entomology.* Smith's "An Explanation of Terms Used in Entomology." Completely revised and rewritten. By J. R. de la Torre-Bueno, Brooklyn Entomological Society, Brooklyn, N. Y., 1937. \$5.00. ix + 336 p. Pl. I-IX. Blue cloth binding, gold lettering.

Twenty-six years ago when I first started to work under Dr. John B. Smith, one of the first books I purchased at that time was a copy of his "Explanations of Terms used in Entomology," which had been published by the Brooklyn Entomological Society in 1906. Having always had a weakness for glossaries, catalogues, directories, and check-lists, it is easy for me to be pleased with Mr. Torre-Bueno's new "Glossary of Entomology," in its attractive blue binding, and with its well printed, legible pages.

To be satisfactory and usable, a glossary should contain, within reason, all terms in current use within its field and I am sure that entomologists will find this new glossary meeting this requirement. The author's position with respect to highly specialized and little used terms, as explained in the introduction, is sound.

Both the author and the publisher should receive the commendation of entomologists for this much needed, and highly useful contribution to entomological literature. The Brooklyn Entomological Society has always encouraged and promoted worth-while contributions to entomology.—H. B. W.

## NEW NORTH AMERICAN FUNGUS GNATS (MYCETOPHILIDÆ)

BY ELIZABETH FISHER

Fifteen undescribed species of fungus gnats were found, while working over some material in the insect collection of Cornell University, as well as new locality records for six others. As thirteen new species of the genus *Bolitophila* have been described since Johannsen's key to the genus appeared in 1909 (Maine Agr. Exp. Sta. Bull. 172) and two more species are described in this paper it seems well to include a key to the species of that genus. Eight new eastern species of the genus *Mycomyia* are described in this paper and a key to these is therefore included. The key to the genus *Bolitophila* includes all the North American forms; the western forms are inserted on the basis of the original descriptions except for *B. bilobata*, *B. subteresa*, and *B. perlata* for which paratype material was available. The key to the genus *Mycomyia* includes only the species of the Atlantic states; western forms are omitted because of lack of material.

I wish to express my thanks to Mr. Frank R. Shaw for his generous loan of specimens; among them the paratypes mentioned above, and also for the specimens upon which the new record of *Bolitophila perlata* and the description of *Mycomyia dentata* are based. He has also looked over many of the new species described here, but for any errors he is in no way responsible.

### KEY TO MALES OF THE GENUS BOLITOPHILA OF NORTH AMERICA

- |  |                        |
|--|------------------------|
| 1. Vein $R_4$ ending in C .....  | 2                      |
| Vein $R_4$ ending in $R_1$ .....   | 11                     |
| 2. Petiole of $Cu$ atrophied at base .....   | 3                      |
| Vein $Cu_1$ atrophied at base .....  | <i>disjuncta</i> Loew  |
| Petiole of $Cu$ and $Cu_1$ not atrophied at their bases .....                            | 4                      |
| 3. Styles with tips "spoon-shaped with the tip chitinized" ( <i>i.e.</i> , sclerotized). |                        |
| .....  | <i>clavata</i> Garrett |
| Styles with tips bifid .....   | <i>recurva</i> Gar.    |
| 4. $Cu_2$ joins the anal vein near its distal end .....                                  | 5                      |
| $Cu_2$ does not join the anal .....  | 6                      |

5. Styles "small, tips bifid, about equal in length" ..... *connectans* Gar.  
     Styles not bifid ..... *alberta* n. sp.
6. Styles with the inner tip ending in a sclerotized point ..... *acuta* Gar.  
     Styles not so ..... 7
7. Sc ends proximad of the base of  $R_s$  ..... 8  
     Sc ends distad of the base of  $R_s$  ..... 9
8. Thorax light in color ..... *distus* n. sp.  
     Thorax dark in color ..... *motana* Coq.
9. Stigma subobsolete; styles "oval with a nose-shaped inner lobe below the  
     middle directed inwards" ..... *bilobata* Gar.  
     Stigma brown; styles not as above ..... 10
10. Styles "sausage-like with the tip constructed smaller, this smaller part  
     ending in two tips" ..... *subteresa* Gar.  
     Styles broad ending in two diverging tips ..... *hybrida* Meig.
11.  $Cu_1$  arises apparently at M either by the fusion with M or by the reduction  
     of the m-cu cross-vein ..... 12  
      $Cu_1$  arises below M; m-cu cross-vein distinct ..... 16
12.  $Cu_1$  fused with M;  $R_4$  straight ..... 13  
      $Cu_1$  arises at M; m-cu cross-vein being greatly reduced ..... 14
13. Subobsolete stigma ..... *atlantica* Fisher  
     Stigma brown ..... *dubiosa* Van Duzee
14. Styles "scoop-shaped (tips truncate with one corner ending in a chiton  
     point" ..... *duplus* Gar.  
     Styles "long, base narrow, tip wider and bifid, outer branch short, inner  
     longer and directed in and upwards" ..... *patulosa* Gar.  
     Styles not so ..... 15
15. Styles without teeth ..... *cinerea* Meig.  
     Styles with a subterminal ventral knob, and two terminal dorsal teeth.  
         *perlata* Gar.  
         (Eastern form)  
         (Western form)
16. Styles "areuate, the chitin tips spiral, appearing bifid, with two strong  
     teeth, unique form" ..... *perlata* Gar.  
         (Western form)  
     Styles "round tapering to a narrow tip shape, the rim chitinized and  
     with two or three black chitin points directed inwards and bristly  
     hairs" ..... *raca* Gar.  
     Styles with an inner sclerotized blade at tip; dorsal edge of the zygoster-  
     num with a mesally projecting lobe ..... *cinerea* Meig.  
     Styles "short dorsally, the base thick, outwardly about halfway straight,  
     then angling to the inner tip. The top truncate" ..... *simplex* Gar.

### ***Bolitophila acuta* Garrett**

A male and a female taken at Coy Glen, New York, May 26, 1934, I place as belonging to this species. This form has hitherto only been recorded from British Columbia. Hypopygium as in figure 3.



***Bolitophila perlata* Garrett**

This species has been taken in the East by C. P. Alexander on the Gaspé peninsula and in Connecticut. The eastern forms have a shorter m-cu cross-vein; the structure of the hypopygium is like that of a western paratype.

***Bolitophila alberta* new species.**

MALE. Length 5 mm. Antennæ fuscous; scape and basal joint of flagellum except its extreme distal end yellow; longer than the head and thorax. Palpi fuscous. Thorax light brown; mesonotum vittate; pleura darkest on anepisternites, sternopleurites, and pteropleurites; scutellum and postnotum dark. Abdomen brown; darkest on the tergites of the first and eighth segments and the posterior margins of segments four, five, six, and seven. Coxæ, trochanters, and femora yellow; tibiæ and tarsi subfuscous; fore tibiæ .94 as long as the fore basitarsi. Wings cinereous tinged; veins brown; pale subobsolescent stigma; Sc enters C distad of midway between the humeral cross-vein and the base of  $R_s$ ;  $R_4$  is straight and ends in C; base of  $R_s$  longer than r-m; petiole of M slightly shorter than the base of  $R_s$ ; m-cu cross-vein is obsolete;  $Cu_2$  curves to join the 2nd anal near its tip. Wing as long as body. Hypopygium as in figure 2.

One male taken at Jasper, Alberta, August 15, 1934. Type (No. 1406) in the Cornell University Collection. This male differs from the male of *Bolitophila montana* Coq. from Ithaca, New York, in the Johannsen collection in having the base of  $R_s$  longer, in having  $Cu_2$  curved towards the tip of the 2nd anal, but not fused with it, and in having  $R_4$  slightly oblique.

***Bolitophila distus* new species.**

MALE. Length 5 mm. Antennæ fuscous; scape and basal flagellar joints yellow; palpi yellow. Thorax yellow; mesonotum with a subobsolete brown vitta on each side. Abdomen brown becoming darker distally. Coxæ, trochanters, and femora yellow; tibiæ and tarsi subfuscous; fore tibiæ .88 as long as the fore basitarsi. Wings hyaline; veins brown; pale subobsolescent stigma; Sc enters C slightly proximad of the base of  $R_s$ ; m-cu cross-vein very short and thick almost obsolete;  $R_4$  ends in C;  $Cu_2$  curves towards the 2nd anal but enters the wing border the length of the petiole of M from the tip of the 2nd anal. Hypopygium as in figure 1.

One male taken at Old Forge, New York, July 20, 1905. Type (No. 1407) in the Cornell University Collection. Close to *B. montana* but differs in the structure of the hypopygium and in color.

***Platyura pellita* new species.**

MALE. Length 4.5 mm. Head fuscous; vertex black; face, mouth parts, palpi, scape, base of first flagellar joint and the ventral half of the first and second flagellar joints yellow; antennæ not compressed. Thorax yellow; mesonotum slightly infuscated mesad; prothorax with black setæ; mesopleura and metapleura bare; first thoracic spiracle with about five hairs on its posterior margin. Legs yellow with black hairs; fore tibiæ longer than the fore basitarsi; distal end of the fore tibiæ with an area of minute reddish brown setæ so closely set together as to appear furry. Wings hyaline; tips very slightly infuscated; Sc ends before the origin of  $R_s$ ;  $R_{2+3}$  slightly oblique, ending in C slightly more than its own length beyond  $R_1$ ; coalesced part of M a little over half as long as the petiole of M; anal vein reaches the margin. Halteres yellow with one strong seta at the base of each. Abdomen yellow except the brown basal half of each tergite. Hypopygium as in figure 11.

Type from N. E. Margaree, Cape Breton I., Nova Scotia, Sept., 1935. Paratype Ithaca, New York, Sept. 5, 1922. Type (No. 1420) in the Cornell University Collection; paratype in my collection.

This species runs to *Platyura setiger* in Johannsen's key (Maine Bull. 172) but differs greatly in coloration and in hypopygium.

***Neoempheria digitalis* new species.**

MALE. Length 5.5 mm. Robust. Head yellow; antennæ yellow, flagellum darker apically; ocellar spot and palpi black. Thorax mainly yellow; mesonotum darker; pleurotergites slightly infuscated; prothorax with six prominent setæ; anepisternites, pteropleurites and pleurotergites bare; mesonotum with strong setæ, more conspicuous at the base of the wings; setæ in rows on the dorsum; scutellum with two very strong setæ. Wings hyaline; apex with a brown cloud extending from the tip of  $R_1$  to the tip of  $Cu_1$ ; spot behind  $Cu_2$ ;  $Sc_2$  and base of small cell  $R_1$  with spot; Sc ends in C over the middle of cell  $R_1$ ; cell  $R_1$  a little less than three times as long as broad; petiole of M about half as long as  $M_1$ ; Cu forks just proximad of the r-m cross-vein; C produced just slightly beyond  $R_s$ . Halteres yellow. Abdomen mainly yellow; hind margin of the first tergite dark; third tergite with two dark spots on the hind margin; fourth, fifth, and sixth tergites with basal spots that extend caudad along the median line; fifth also with lateral black spots; seventh tergite infuscated except its yellow base; venter yellow. Hypopygium (figure 18) yellow; its digit-like spines black.

Type from Douglas Lake, Mich., August 12, 1922. This species runs to *N. macularis* Joh. in Johannsen's key (Maine Bull. 180). *N. digitalis* is larger; differs greatly in its hypopygial structure from *N. macularis*; cell  $R_1$  is not entirely covered by a spot; and the palpi are black.

A female from Douglas Lake, Mich., is similar to the male except it is about 6.5 mm. in length; has a differently colored abdomen with the dorsum of the first tergite, the hind margins of the second and third, all of the fourth segment except the base, and the remaining tergite dark; venter yellow.

Type (No. 1418) and allotype in the Cornell University Collection.

#### KEY TO THE MALES OF THE GENUS MYCOMYIA OF THE ATLANTIC STATES

*Mycomyia nugatoria*, *M. onusta*, *M. unicolor* and *M. incompta* are known from the females only and are therefore omitted from this key.

1. Fork of Cu below or distad of the base of  $R_s$  ..... 2  
     Fork of Cu proximad of the base of  $R_s$  ..... 17
2. Spurs present on the mesothoracic coxæ; usually two scutellar bristles.... 3  
     Spurs absent; usually four scutellar bristles ..... 6
3. Fore basitarsus longer than its tibia ..... 4  
     Fore basitarsus shorter than its tibia ..... *appendiculata* Lw.
4. Petiole of M longer than  $M_3$  ..... *sequax* Joh.  
     Petiole of M shorter than  $M_3$  ..... 5
5. Coxal spurs short ..... *imitans* Joh.  
     Coxal spurs long; hypopygium figures 7 & 9 ..... *dichaeta* n. sp.
6. Abdomen with two or three spots on each segment; petiole of M shorter than  $M_3$  ..... *biseriata* Lw.  
     Abdomen not marked as above; petiole of M equal, shorter than, or longer than  $M_3$  ..... 7
7. Hypopygium as in figure 10 ..... *dentata* n. sp.  
     Hypopygium not so ..... 8
8. A dense brush of setæ on the fore coxæ ..... *ornata* Meig.  
     No dense brush of setæ on the fore coxæ ..... 9
9. Sc ends in  $R_1$  ..... 10  
     Sc ends in C or is free ..... 11
10. Thorax vittate; base of first abdominal segment dusky ..... *littoralis* Say  
     Thorax not vittate; hypopygium figure 5 ..... *alternata* n. sp.
11. Petiole of M shorter than  $M_3$  ..... 12  
     Petiole of M longer or subequal to  $M_3$  ..... 13
12. Abdomen yellow; posterior third or half of each tergite blackish, sixth and seventh tergites black; 3 to 5 mm. in total length. *brevivittata* Coq.  
     Abdomen yellow; tergites black except the wide posterior margin; 6 mm. in total length ..... *mendax* Joh.
13. Dorsum of thorax fuscous black, with black pile; humeri yellowish; scutellum fuscous black ..... *obtruncata* Lw.  
     Thorax yellow with dorsal markings ..... 14
14. Dorsum of thorax with distinct black or reddish markings;  $Sc_2$  usually at the middle of cell  $R_1$  ..... 15

- Dorsum of thorax with faint markings;  $Sc_2$  before the middle of cell  $R_1$ ; petiole of M and  $M_3$  subequal ..... *nigricauda* Adams
15. Two scutellar bristles ..... *sigma* Joh.  
Four scutellar bristles ..... 16
16. Mesonotum with two oblique lines which meet at the scutellum; a median stripe and two elongate lateral spots dorsad of the wing bases.  
*obliqua* Say  
Mesonotum with three confluent or subconfluent dusky stripes.  
*tantilla* Say
17. No spurs on the mesothoracic coxæ; fore tibiæ longer than their basitarsi; four scutellar bristles ..... 18  
With spurs present on the mesothoracic coxæ; two or four scutellar bristles ..... 19
18. Thorax yellow; bases of abdominal segments black; total length 5 mm.  
*flavohirta* Coq.  
Thorax dark; hind borders of abdominal segments black, bases yellow; hypopygium figures 4 & 8 ..... *turitella* n. sp.
19. Spurs of the mesothoracic coxæ minute; posterior margins of abdominal tergites black; fore basitarsus longer than its tibia ..... *imitans* Joh.  
Spurs of mesothoracic coxæ long ..... 20
20. Scutellum with four setæ ..... 23  
Scutellum with two setæ ..... 21
21.  $Sc_2$  ends before the center of cell  $R_1$ ; length 3.5 mm.; both anterior and posterior margins of the tergites yellow; hypopygium as in figures 13, 14, 15 ..... *hirticollis* Say  
 $Sc_2$  ends before the center of cell  $R_1$ , sometimes but slightly so; abdomen fuscous with yellow posterior margins ..... 22
22. Fore basitarsus shorter than its tibia; hypopygium as in figures 12 & 13.  
*curvata* n. sp.  
Fore basitarsus longer than its tibia; hypopygium as in figures 20 & 21.  
*scopula* n. sp.
23. Length 6.5 mm.; thorax yellow; three stripes on the mesonotum dark brown, middle one produced cephalad, laterals short, all three confluent posteriorly; hind coxæ infuscated; head infuscated becoming darker near the ocelli ..... *maxima* Joh.  
Not as above ..... 24
24. Coxæ fuscous; hypopygium as in figure 22, its dorsal aspect similar to that of *M. scopula* in figure 20 ..... *parascopula* n. sp.  
Coxæ yellow ..... 25
25. Pleura yellow; scutellum yellow; head infuscated ..... *sequax* Joh.  
Pleura blackish; scutellum blackish; head shining black; hypopygium as in figure 19 ..... *pseudomaxima* n. sp.

The European species, *Mycomyia ornata* Meig., was taken at McLean, New York, in August. The postnotum has the characteristic few bristles and the fore coxæ have the brush-like group



of setæ. There are two types of hypopygia represented. One is like that figured by Edwards (Trans. Lond. Ent. Soc., 1925); this specimen has the fore tibia subequal to the fore basitarsus. The other is like that figured by Dziedzicki (Publications de la Société des sciences de Varsovie III. 1915.) as *Sciophila tumida* Winn.; this specimen has the fore basitarsus longer than its tibia. Edwards suggests that *M. tumida* is a synonym of *M. ornata*. He says: "The male hypopygium shows a certain amount of variation but most of those I have examined agree more or less closely with Dziedzicki's figures of *Mycomyia tumida*. For this reason I think it possible that Dziedzicki has merely figured as *M. ornata* an abnormal or damaged specimen of the same species which he has shown in a different position as *M. tumida*."

Two other North American species have this fore coxal brush, *Mycomyia durus* Garrett and *Mycomyia armata* Garrett.

*Mycomyia hirticollis* has been taken on Cape Breton Island, Nova Scotia, in August. Figures 13, 14, and 15 show the hypopygium of this species; they are included here as there are no published figures of this species.

*Mycomyia sigma* Joh. originally recorded only from North Carolina has been taken at the Wild Flower Preserve, Slaterville, New York, and also at Fillmore Glen, Moravia, New York.

*Mycomyia sequax* Joh. originally recorded from Ithaca, New York, has been taken at Jasper, Alberta.

***Mycomyia pseudomaxima* new species.**

MALE. Length 2.5 mm. Head black; palpi, scape, and base of first flagellar joint yellow; proboscis dusky. Thorax dusky black except the prothorax and the membranous areas surrounding the stigmata and the wing bases. Legs yellow; spurs of the mesothoracic coxæ slender, reaching up to about two thirds the length of the fore coxæ, the tip bearing two minute black teeth; fore tibiæ longer than the fore basitarsi. Halteres yellow. Wings hyaline; Sc ends in C over distal end of cell  $R_1$ ;  $Sc_2$  over middle of cell  $R_1$ ; cell  $R_1$  about twice as long as wide;  $R_{4+5}$  ends nearly at the wing tip; the petiole of M longer than  $M_2$ ; Cu forks below the r-m cross-vein. Abdomen fuscous; venter and the narrow posterior margins of tergites yellow. Hypopygium (superficially like *M. maxima*) as in figure 19.

Holotype taken at Ithaca, New York, May 24, 1934. Type (No. 1411) in the Cornell University Collection.

***Mycomyia parascopula* new species.**

MALE. Length 4 mm. Head black; palpi subfuscous; scape subfuscous (flagellum missing). Thorax mainly fuscous; prothorax yellow with four or five subprominent setæ; mesonotum with three fuscous stripes, the laterals abbreviated anteriorly, the three confluent caudad; scutellum yellowish with four prominent setæ; postnotum and pleura fuscous. Legs yellow; posterior coxæ fuscous; spurs on the mesothoracic coxæ longer than the coxæ, tapering distally to the two black terminal teeth. Wings hyaline; Sc ending in C distad of the middle of cell  $R_1$ ; cell  $R_1$  less than twice as long as wide; petiole of M shorter than  $M_3$ ; C ends at  $R_{4+5}$  at the wing tip; Cu forks proximad of the r-m cross-vein. Halteres yellow. Abdomen fuscous; posterior margins of the tergites yellow. Hypopygium as in figure 22.

Type from Beltsville, Md., Oct. 22, 1915. W. L. McAtee collector. Type (No. 1410) in the Cornell University Collection.

***Mycomyia dictaeta* new species.**

MALE. Length 4 mm. Head brown; proboscis, palpi, scape, and basal joint of flagellum yellow. Thorax mainly yellow; prothorax yellow with two prominent and five smaller setæ on each side; mesonotum with three stripes, a median brown stripe produced to the anterior margin, two lateral brown stripes abbreviated anteriorly, the three stripes confluent posteriorly before the level of the wing bases, the remainder of the mesonotum dark brown; scutellum and postnotum brown, yellow laterally; anepisternites and sternopleurites brown; pleurotergites brown on their ventral and caudal margins; scutellum with two prominent setæ. Legs yellow; distal end of hind coxæ with an oblique line of short setæ on their caudal aspects; mesocoxal spurs long slender tapering gradually to a point which lacks teeth; fore tibiae and fore basitarsi subequal in length. Wings hyaline; C ends at  $R_{4+5}$ ; Sc long ending in C just proximad of the middle of cell  $R_1$ ;  $Sc_2$  over proximal end of cell  $R_1$ ; cell  $R_1$  over twice as long as wide;  $R_{4+5}$  ends at the wing tip; petiole of M less than half as long as  $M_3$ ; Cu forks distad of the r-m cross-vein; indications of a spurious vein between  $R_s$  and M which ends before the wing margin. Abdominal segments brown with broad yellow posterior margins. Hypopygium as in figures 7 and 9.

Type from Fillmore Glen, Moravia, New York, June 28, 1935. Paratypes from the Wild Flower Preserve, Slaterville, New York, and Lick Brook, Ithaca, New York, Oct. 10, 1935. Type (No. 1415) in the Cornell University Collection. Paratypes in my collection.

***Mycomyia scopula* new species.**

MALE. Length 4 mm. Head dark brown; proboscis, palpi, scape, and basal joint of flagellum yellow. Thorax mainly yellow; prothorax yellow with three

to five prominent setæ; mesonotum yellow with three faint stripes, the median one continued anteriorly to the collar, the laterals abbreviated anteriorly; postnotum and sternopleurites slightly infuscated. Legs yellow; fore basitarsi longer than their tibiæ; mesothoracic coxæ with long spurs, each tapering to a black tip. Wings hyaline; C ends at  $R_{4+5}$ ; Sc long ending in C just beyond the middle of cell  $R_1$ ;  $Sc_2$  just beyond the middle of cell  $R_1$ ; cell  $R_1$  twice as long as wide;  $R_{4+5}$  ending at the wing tip; petiole of M longer than  $M_3$ ; Cu forks below the r-m cross-vein. Abdomen fuscous; venter and narrow posterior margins of the tergites yellow. Hypopygium (superficially like *M. maxima*) as in figure 19.

Holotype taken at Ithaca, New York, May 24, 1934. Type (No. 1411) in the Cornell University Collection.

***Mycomyia turitella* new species.**

MALE. Length 3.5 mm. Head fuscous dorsally; front and lateral portions yellowish; palpi yellow their proximal ends darker; antennæ light brown except the scape and basal flagellar joint which are yellow. Thorax mainly yellow; three confluent stripes on the mesonotum, the median light brown and continued anteriorly to the collar, the laterals abbreviated anteriorly and black in color; lateral portions of the mesonotum above the wing bases and anterior as far as the ends of the lateral stripes fuscous; prothorax and humeri yellow; prothorax with four prominent bristles; scutellum fuscous with four subprominent bristles; postnotum yellow, fuscous caudad; anepisternites, sternopleurites, and pleurosternites fuscous. Coxæ yellow; mesothoracic coxæ without spurs; fore tibiæ longer than fore basitarsi. Halteres yellow. Wings hyaline; Sc long ending in C over the distal end of cell  $R_1$ ;  $Sc_2$  over the middle of cell  $R_1$ ; C ends at  $R_{4+5}$  before the wing tip; cell  $R_1$  about twice as long as wide; petiole of M shorter than  $M_3$ ; Cu forks proximad of the r-m cross-vein. Abdomen fuscous; bases of tergites yellow. Hypopygium as in figures 4 and 8.

Described from one male collected by W. A. Hoffman at Monticello, Fla., March 8, 1919. Holotype (No. 1408) in the Cornell University Collection.

***Mycomyia curvata* new species.**

MALE. Length 5 mm. Head fuscous; palpi, scape, and basal third of first flagellar joint yellow. Thorax fuscous, prothorax yellow with five subprominent setæ; mesonotum with three narrow confluent yellow stripes, the laterals abbreviated anteriorly; pleura fuscous. Legs yellow; hind coxæ slightly dusky; mesothoracic coxal spurs longer than their coxæ and tapering distally to the two black teeth; the fore basitarsi longer than their tibiæ. Abdomen with six visible abdominal segments; fuscous; with the narrow posterior margins of the segments yellow; venter yellow basally, distad fuscous. Hypopygium subfuscous (figures 12 and 17).

Type collected at Beaver Lake near Jasper, Alberta, August 15, 1934. Paratypes from Beaver Lake and a defective paratype from Katahdin, Maine, August, 1913 (3,000 feet), collected by C. P. Alexander. Type (No. 1414) in the Cornell University Collection.

***Mycomyia alternata* new species.**

MALE. Length 3 mm. Head black; palpi, proboscis, and flagellum black; scape yellow. Thorax yellow; prothorax with three prominent setæ; mesonotum without stripes; scutellum with four prominent setæ; postnotum subfuscous caudad; pleura yellow, except the subfuscous pleurotergite. Legs yellow; mesothoracic coxæ lack spurs; fore tibiæ longer than the fore basitarsi. Wings hyaline; Sc ends in  $R_1$  at about the middle of cell  $R_1$ ; C ends at  $R_{4+5}$  before the tip of the wing; cell  $R_1$  about three times as long as wide;  $M_3$  longer than the petiole of M; Cu forks distad of the r-m cross-vein. Halteres yellow. Abdomen yellow; posterior margins of the tergites brown. Hypopygium as in figure 5.

Type from McLean Reservation, McLean, New York. August. Type (No. 1413) in the Cornell University Collection.

***Mycomyia dentata* new species.**

MALE. Length 3.5 mm. Head fuscous; mouth parts, palpi, scape, and base of first flagellar joint yellow. Thorax brown; prothorax with three strong setæ; mesonotum with indications of three dark stripes; scutellum with four strong setae. Legs yellow. Halteres yellow. Wings hyaline; Sc ends in  $R_1$  before the middle of cell  $R_1$ ; cell  $R_1$  twice as long as wide;  $Sc_2$  absent; C ends at  $R_{4+5}$  before the wing tip; petiole of M longer than  $M_2$ ; Cu forks distad of the r-m cross-vein. Hypopygium as in figure 10.

Type from Shelburne, N. H., collected by C. P. Alexander. Type (No. 1416) in the Cornell University Collection.

***Mycomyia intermedia* new species.**

MALE. Length 4 mm. Head black; palpi, proboscis, and antennæ black except the basal part of the first flagellar joint which is yellow. Thorax black; the three stripes of the mesonotum separated by shining areas; humeri lighter; pleura black; prothorax black with about five prominent setæ. Coxæ dusky; spurs of the mesothoracic coxæ little longer than the trochanters, their bases dark, yellow distad, ending in two black teeth; fore tibiæ longer than the fore basitarsi. Wings hyaline with a small black spot at the base of Cu; C ends at  $R_{4+5}$  at the wing tip; Sc ends in C over the proximal end of cell  $R_1$ ;  $Sc_2$  over the proximal end of cell  $R_1$ ; cell  $R_1$  about twice as long as wide; petiole of M shorter than  $M_3$ ; Cu forks just proximad of the r-m cross-vein. Halteres yellow. Abdomen black. Hypopygium as in figure 23.



Type from Fair Oakes, Calif., May 10, 1918. Type (No. 1412) in the Cornell University Collection.

This species is apparently close to *Mycomyia fuscibasis* Van Duzee, but differs in leg proportions and in the hypopygial structure. The antennal bases have less yellow. Sc ends proximad of the middle of cell  $R_1$ . In Johannsen's key it runs down to *M. calcarata*, but is separable from that species by having the petiole of M less than half as long as  $M_1$ ; the spurs of the middle coxæ are less than half the length of the coxæ; cell  $R_1$  more than 1.5 times as long as broad; and the mesonotal stripe is not distinctly divided.

The differences between the new eastern species and other species are shown in the key.

***Docosia paradichroa* new species.**

MALE. Length 4.5 mm. Head and antennæ black; palpi subfuscous, lighter distad. Thorax wholly black, shining. Legs yellow, tarsi are infuscated distally; fore basitarsi shorter than their tibiæ. Halteres yellow. Wings hyaline; Sc ends in  $R_1$ ; r-m cross-vein longer than the stem of M; fork of Cu proximad of the fork of M and proximad of the tip of Sc. Abdomen mainly yellow; sixth segment with diffuse black spot on both tergite and sternite; eight and ninth segments wholly black. Hypopygium (figure 6) black.

Type and three paratype males taken at the Wild Flower Preserve, Slaterville, New York, May, 1935. Feeding on slime flux of maple. Type (No. 1417) in the Cornell University Collection; paratypes in my collection. This species resembles *Docosia dichroa* Loew but differs in the structure of the hypopygium, in lacking the group of numerous black spines on the inner tip of the hind tibia and in possessing two short, black, peg-like spines anterior to the hind tibial spurs.

***Exechia clepsydra* new species.**

MALE. Total length 4.5 mm. Head deep fuscous; palpi, scape, and first flagellar joint yellow. Thorax chiefly fuscous; prothorax yellow with five setæ on each side; mesonotum deep fuscous; pleurotergites with six prominent setæ; scutellum with two small setæ, followed posteriorly by two large setæ; hypopleurite yellow. Legs yellow; fore basitarsi longer than their tibiæ; base of middle and hind femora with an oval brown spot beneath. Wings hyaline; Sc short ending in  $R_1$ ; curvature of  $R_s$  not conspicuous. Halteres yellow. Abdominal tergites mainly fuscous; first tergite with a minute basal yellow triangle; tergite three with lateral yellow spots which cut laterally into the dorsal

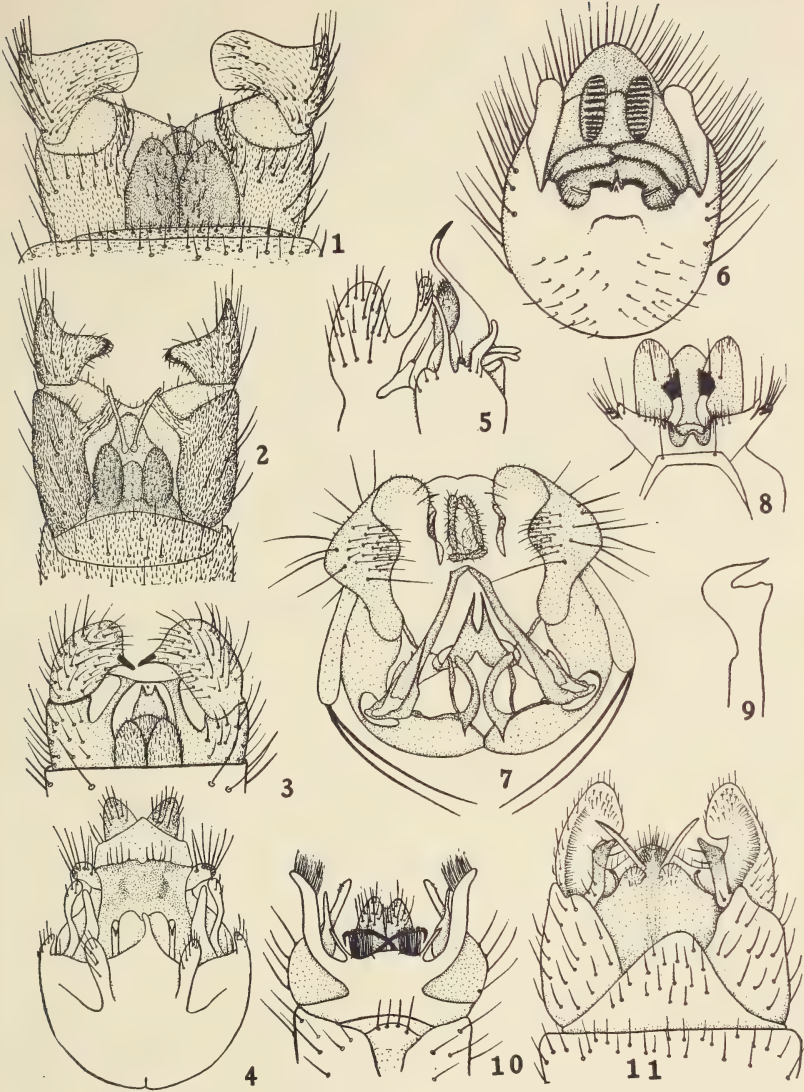
brown making almost an hour-glass shaped mark (hence the specific name). Hypopygium (figure 18) yellow.

Type from Fillmore Glen, New York, Nov. 18, 1934. Type (No. 1419) in the Cornell University Collection. In Johannsen's key this runs down near *E. capillata* and *E. absoluta* but differs greatly in the form of the hypopygium as well as in the color and in leg proportions.

#### PLATE 29

1. *Bolitophila distus* dorsal\* aspect of hypopygium.
2. *Bolitophila alberta* dorsal aspect of hypopygium.
3. *Bolitophila acuta* dorsal aspect of hypopygium.
4. *Mycomyia turitella* ventral aspect of hypopygium.
5. *Mycomyia alternata* lateral aspect of hypopygium.
6. *Docosia paradichroa* ventral aspect of hypopygium.
7. *Mycomyia dichæta* caudal aspect of hypopygium.
8. *Mycomyia turitella* dorsal aspect of hypopygium.
9. *Mycomyia dichæta* lateral aspect of forceps (styli).
10. *Mycomyia dentata* dorsal aspect of hypopygium.
11. *Platyura pellita* ventral aspect of hypopygium.

\* Refers to the morphological dorsal, ventral, and lateral aspects and not to the actual aspects which may vary in different individuals.

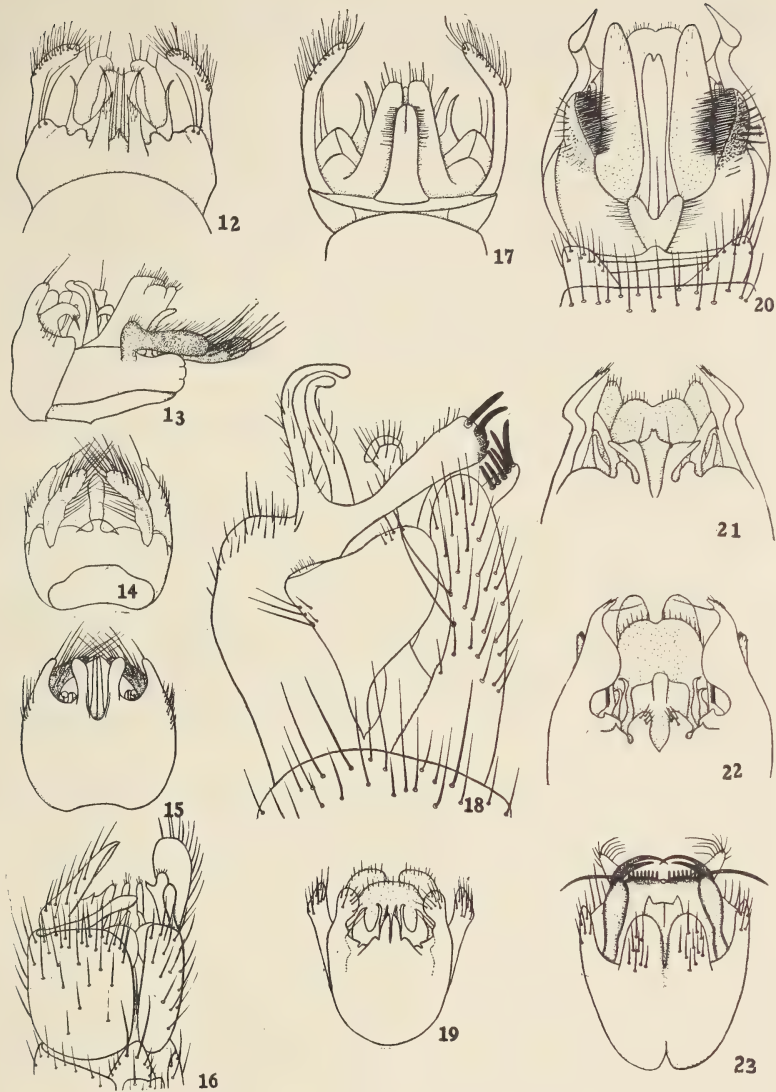


MYCETOPHILIDÆ

## PLATE 30

12. *Mycomyia curvata* ventral aspect of hypopygium.
13. *Mycomyia hirticollis* lateral aspect of hypopygium.
14. *Mycomyia hirticollis* dorsal aspect of hypopygium.
15. *Mycomyia hirticollis* ventral aspect of hypopygium.
16. *Exechia clepsydra* latero-ventral aspect of hypopygium.
17. *Mycomyia curvata* dorsal aspect of hypopygium.
18. *Neoempheria digitalis* lateral aspect of hypopygium.
19. *Mycomyia pseudomaxima* ventral aspect of hypopygium.
20. *Mycomyia scopula* dorsal aspect of hypopygium.
21. *Mycomyia scopula* ventral aspect of hypopygium.
22. *Mycomyia parascopula* ventral aspect of hypopygium.
23. *Mycomyia intermedia* ventral aspect of hypopygium.





MYCETOPHILIDÆ

## NOTE ON GIANT SWALLOW-TAIL BUTTERFLY IN NEW JERSEY

*Papilio cresphontes* Cr., the largest of our swallow-tails, is of rather wide distribution but apparently somewhat local. In the South the larva is known as the "Orange Dog"; in the more northern states its food plants are Prickly Ash (*Zanthoxylum americanum* Mill.), Hop Tree (*Ptelea trifoliata* L.) and occasionally American Bladdernut (*Staphylea trifolia* L.), where these occur. In southern New Jersey the species is rarely seen, but last August one female was noticed for about a week in Moorestown, Burlington County, where she oviposited on an isolated Bladdernut shrub on the property of Edward Haines. The larvæ developed in due course and scattered for pupation.

In the hills of northern New Jersey, however, the giant swallow-tail is not uncommon. Here are considerable patches and borders of Prickly Ash and Bladdernut. During the past season (1937) larvæ of various sizes were, it seemed to me, unusually plentiful on Prickly Ash throughout the summer and autumn. The larvæ, with an odd pattern of olive and white, strongly resemble bird-droppings. The pupæ, similarly colored, seem to be constant in this character instead of varying to brown or green as in *polyxines* and *troilus*.

The locality of greatest abundance for *cresphontes* appears to be the limestone foothills of the Jenny Jump Mountains in Warren County.—R. J. S.

## THE VERMIN KILLER: 1775 MODEL

BY HARRY B. WEISS

In 1775 there was printed in London for S. Bladon of Lombard Street, a little book ( $5\frac{1}{4} \times 3$  inches) of 52 pages entitled: "The Vermin-Killer: Being A very necessary Family-Book, Containing Exact Rules and Directions for the artificial killing and destroying all Manner of Vermin, *viz.* Bugs, Rats and Mice, Fleas and Lice, Moles, Pismires, Flies, Catterpillars, Snakes, Weasles, Frogs, etc. Whereunto is added, The Art of taking all Kinds of Fish and Fowl, with many other Things never before known."

The author of this treatise, one W. W., wrote in the preface that he had brought his material together because, many times, mankind is more disturbed by small and inconsiderable insects than by the more noble species of sensitive creatures. Furthermore the "infallible remedies" laid down by him were deduced not only from the writings of learned and judicious authors, but also from the constant experiences of various persons who had tried the remedies and had benefited therefrom.

The remedies in this little book are typical of the brand of economic entomology that flourished before anyone thought of bringing "economic" and "entomology" together, and at a time when the entomologists themselves were not concerned with such a "low" phase of their subject.

Because of their quaintness some of these remedies are reproduced herewith just as they appear in "The Vermin-Killer."

### *To kill Bugs*

Take a convenient quantity of fresh tar, mix it with the juice of wild cucumber, let it stand a day or two, stirring it four or five times in a day, then annoint the bedsteads with it, and all the bugs will die.

### *Another*

Take the gall of an ox, and mix it with vinegar, and rub the cracks and joints of the bedstead with it, and all the bugs will die in a short time.

*Another*

Take a quantity of brimstone, beat it to powder, then mix the powder with old oil, and use it as before.

*Another*

Take strong glue, and boil it with vinegar, and rub the bedsteads with it, and the bugs will certainly die.

*Another*

Take quick-silver and mix it with hog's grease, of each a like quantity, use it as before.

*To kill Pismires*

Take the roots of wild cucumbers, and set them on fire where the pismires are, and the smoke will kill them.

*To drive away Pismires*

Take an earthen dish, full of pismires and the earth where they are, and make a good fire, and put the earthen pot on the fire, and the pismires will not remain near that place.

*Another*

Take mussel shells, burn them with storax, and beat them to a small powder, and straw the powder where the pismires usually are, as the great banks, and they will all come out of their holes, and kill them.

*To keep the Sugar box or Spice from the Pismires*

Cover your sugar box with white wool, or annoint it with rubica.

*To kill Fleas*

Take wormwood, and the root of wild cucumber, and boil them in pickle, and sprinkle it in the room, and it will certainly kill the fleas.

*Another*

Take soap lees, and boil two or three onions in it, let it cool, then sprinkle the room with it, and it kills the fleas.

*Another*

Take lee and she-goat's milk, and it is an infallible remedy.



*To gather all the Fleas together that are in the Room*

Take an earthen pot, and cut a hole in the floor of the room, so big as the pot may stand with the mouth even with the floor of the room, then take the blood of an ox, and mix it with the soot of a chimney, and rub it in the inside of the pot, and all the fleas will come into the pot in a day's time.

*Another*

Take a small piece of wood, as big as a man's arm, and rub it over with hog's grease, and all the fleas will gather to it, if you lay it in the middle of a room.

*Another*

Take the blood of a bear or badger, and put it under the bed as before, and it gathers the fleas to it, and they die immediately.

*To kill Lice*

Take salt water and rub the afflicted places with it, or vinegar, or onion, and mix in it allum and aloes, and therewith annoint the place.

*Another*

Take hog's lard, quicksilver, and sage, as much of each as is needful, mix them together to a salve, and annoint the afflicted places.

*To kill crab Lice*

Take a roasted apple, and take the skin and core from it, and beat it in a mortar with as much quicksilver as will make it into an ointment, and therewith dress the afflicted places.

*To kill Caterpillars*

Take fig leaves ashes, and cast it on the root, and it destroys caterpillars.

*Another*

Take a gallon of crabs, and steep them ten days in water, and sprinkle the trees with the water, and it kills the caterpillar.

*Another*

Take a quart of the morning-dew, and mix in it verdegreaase, or for want of that, take such a quantity of the juice of four

crabs, and mix a little verdegrease in it, sprinkle the root, branch, or place so infected and it certainly kills them.

*To kill Flies*

Take white hellebore, and steep it in sweet milk, mix with it orpiment, and sprinkle the room, and places where the flies come, and they will all die.

*To gather the Flies together*

Take a deep earthen pot, and lay in it beaten colliander, and all the flies in the house shall be gathered together.

*To keep Cattle from injury by Flies*

Anoint the beast with oil, wherein bakeler hath been boiled, and the flies shall not come near him.

The compounds advocated for insect control in "The Vermin Killer," include tar, vinegar, ox gall, ox blood, sulphur, glue, oil, hog's grease, wax, quicksilver, soap dregs, lime, goat's milk, salt water, alum, olive oil, ashes of fig leaves, saltpetre, sheep's dung, verdegreis, mussel shells, red orpiment and botanical remedies involving the use of wild cucumbers, ivy, wormwood, rue, white hellebore, Marjoram, Lupine, Daphne, mustard seed, aloes, lavender, *Amaranthus*, *Scilla*, *Scolopendrium*, etc.

At first glance these may seem to be more antiquated than they really are. As a matter of fact, the forerunner of the economic entomologist had at his disposal, oil, glue, sulphur, mercury, arsenic, soap lime, etc., even though he did not use them as knowingly or as intelligently as they are being used today.

The non-entomological remedies in "The Vermin Killer" are of the same type as the entomological ones. "To gather together all the Rats and Mice into one Place in a House or Barn, and to kill them," one was supposed to "Take two or three living rats or mice, and put them into an earthen pot, then stop the pot close, that the rats or mice cannot come forth, then make a fire of ashen-tree wood, and place the pot on the fire, when it burneth moderately, and all the rats and mice in the house, hearing the cry of those in the pot, will run immediately to the place where the pot standeth on the fire, as if they did intend by force to deliver the rats and mice in the pot."

I have not attempted to identify W. W. who wrote "The Vermin Killer." It would be interesting to know if he made other economic contributions to entomology and also something of his entomological life but—an ocean, and the 162 years between me and his uncertain literary remains are obstacles which I have no ambition to overcome at this time.

## NEW JERSEY LACE BUG NOTES

In Circular No. 54, N. J. Dept. Agric. (1922), "The Lace Bugs of New Jersey," by Weiss and Barber, the Elm Lace Bug (*Corythuca ulmi* O. & D.) is mentioned as of probable occurrence in this state, but no record is given. In the Weiss collection of *Tingitidæ* I find several specimens of *ulmi* marked "Beatyestown, N. J. IX-20"—no year indicated. Doubtless these were collected after the publication of the paper of 1922.

On August 13, 1937, a small infestation of *ulmi* was discovered on young elms along the river road near Lambertville, N. J. Thirty specimens were collected.

In 1936, near Byram, a few miles up the Delaware from Lambertville, a good colony of the large and beautiful *Corythuca bulbosa* O. & D. was discovered on its food-plant, American Bladdernut. This species was found several years ago by Weiss near Monmouth Junction, but had not been reported as occurring elsewhere in New Jersey.

In the fall of 1936 a few specimens of the Fringe Tree Lace Bug [*Leptoypha mutica* (Say)] were found on native *Chionanthus* along the Maurice River near Vineland. A number of years ago the species was seen in numbers by Mr. Weiss in a nursery in Hammonton, N. J., but was not located on native trees.—R. J. S.



## PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF FEBRUARY 2, 1937

A regular meeting of the Society was held on February 2, 1937; President Curran in the chair with twenty-three members and thirty-five visitors present.

The program committee reported that the next session would be given over to a general discussion of "Methods of Rearing Insects," led by Miss Lucy W. Clausen.

The following were proposed for active membership: Mr. Norman L. Rump, 244 W. 104th Street, New York City; Mr. W. N. Boyd, Millerick Ave., Trenton, New Jersey, R. D. No. 4, and Miss Dora Harris, 16 South Broad Street, Elizabeth, New Jersey.

Dr. A. L. Melander called attention to the death of Professor Brunner, an Orthopterist of California.

Dr. Horsfall made a motion, seconded by Dr. Moore, that the chair appoint a committee to take under consideration and report within two months, to the executive committee for action, the desirability of forming a junior membership class.

The President announced that he would name the committee at the next meeting of the Society.

Dr. C. C. Hamilton, the speaker of the evening, was then introduced. Mr. Hamilton's topic was the "Use of the Airplane and Autogyro in Insect Control." Some problems that have already been treated successfully are—the control of cotton insects in the South, tomato worms in California, blunt-nosed leafhopper in cranberries in N. J., leafhoppers on beets in the West, grasshopper poison bait in the Middle West. The great problem to be faced is the prevention of drifting of the sprays. In this connection it has been found that a concentrated arsenical spray will not drift as much as a dust spray. By the addition of petroleum oil evaporation is prevented.

In striving to take up a greater pay-load most of the time is taken up in loading and in the preparation of equipment. The cost of dusting is therefore dependent upon the pay-load. An airplane goes along on an even keel and the dust gradually spreads and settles. The autogyro, however, flies at an angle and makes for better distribution.

A general discussion of Mr. Hamilton's paper closed the evening's meeting.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF FEBRUARY 16, 1937

A regular meeting of the Society was held on February 16, 1937; President Curran in the chair with twenty-eight members and twenty-three visitors present.

The following were elected to active membership: Miss Dora Harris, Messrs. Rump and Boyd. The by-laws were suspended in order to elect Dr. Nellie M. Payne to active membership.

Dr. Curran announced the committee on Junior Membership as follows: Mr. M. Kisliuk, Mr. A. J. Mutchler, Mr. Bird, Dr. Ruckes, Dr. Horsfall.

A discussion, by members, on "Methods of Rearing Insects," occupied the rest of the meeting.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF MARCH 2, 1937

A regular meeting of the Society was held on March 2, 1937; President Curran in the chair with twenty-seven members and twenty-one visitors present.

Dr. Klots spoke on "Lepidoptero-geography in the Rocky Mountains." A series of lantern slides illustrating the chief environments and Life Zones, as well as details of some plant successions, was shown.

LUCY W. CLAUSEN, *Secretary*.

An abstract of the remarks by Dr. Klots follows.

The following mountain ranges were investigated in 1936:

#### HALL VALLEY, COLORADO

Worked thoroughly from 13,000 ft. down to 9200. *Brenthis frigga sagata* Barnes & Benjamin was found at 9200 ft. in a senescent, acid bog that was growing up to heath. *Brenthis aphirabe alticola* Barnes & McDunnough was found in grass and sphagnum bogs from 9500 ft. to 11,000 ft. A new species of *Crambus* was taken in Hudsonian Zone at about 11,200'; this species has also been taken by the author on Pike's Peak and in the Snowy Range, Wyo., and by Dr. Brower in nearly identical environment on Mt. Katahdin, Maine—a striking example of Life Zone distribution.

#### SANGRE DE CRISTO RANGE, NEW MEXICO

Collecting in lower and middle Canadian Zone. A good series of a new race of *Colias scudderi* was taken in grassy, *Iris-Rudbeckia* meadows.

#### SAN FRANCISCO MTS., ARIZONA

The range was badly desiccated, and collecting was very poor. A range surrounded by desert must have a considerable area of forest around the high peaks, or else the hot, drying desert winds will prevent the formation of any great area of tundra above timberline. This is constantly happening here; in addition the whole interior of the range has been badly burned, and there has been much overgrazing.

#### TUSHAR RANGE, UTAH

Bad weather, with heavy rains and hailstorms, prevented much collecting above timberline. There is a considerable area of true Arctic-Alpine Zone,

and interesting forms should occur here; for this is the most southern of the Utah ranges to possess any considerable area of true tundra.

#### UINTAH MTS., UTAH

Considerable collecting was done on the mountains surrounding the Mirror Lake Basin. On Mt. Murdock, *Erebia magdalena* Strecker was found in abundance, over 40 specimens being taken in one morning. This species and *Lycaena snowi* Edwards are definitely very petrophilous, flying by choice over barren rockslides on steep slopes. On a lower shoulder of Hayden Peak, an *Oeneis* of the *brucei-semidea* group was taken. This group of *Oeneis* is found only in extreme Arctic-Alpine tundra environment, and serves as an indicator for this zone. The other group of the genus, comprising such species as *chryxus* and *jutta* are found at lower elevations, often down to the middle Canadian Zone.

#### LA SAL MTS., UTAH

Very few of the typical high altitude butterflies were taken in this range, but such as occurred (*Lycaena snowi*, *Brenthis helena* and *Parnassus smintheus*) show that the relationship of this part of the fauna is definitely with the Colorado mountains which lie to the East of the range, rather than with the Utah mountains to the North and West. The range is surrounded by hot, dry desert, which must effectively bar any present-day exchange of high altitude butterflies with other ranges.

#### SAN JUAN MTS., COLORADO

In the course of collecting at high altitudes in this range, such famous peaks as the Wetterhorn and Uncompaghre were climbed by some of the party, and interesting faunal and floral observations were made. *Oeneis uhleri* was taken in Upper Canadian Zone, on a lush mountainside; this is one of the "low altitude group" of the genus. A large series of an undescribed species of *Crambus* was taken at camp, which was located at the formerly flourishing, now nearly deserted, mining camp of Capitol City. *Erebia callias* was taken at the base of the final slope of the Wetterhorn; but *Erebia demmia* Warren, recently described from material taken in the San Juans on a former trip by Mr. Whitmer, of our party, and Mr. Davenport, was not found.

#### MEETING OF MARCH 16, 1937

A regular meeting of the Society was held on March 16, 1937; President Curran in the chair with twenty-eight members and seventeen visitors present.

The speaker of the evening, Dr. Argo, then told about beehives and apiaries. Dr. Argo said that a study of bees is a study of insect psychology. They have a long list of instinctive responses which bear only upon the preservation of the species and not the individual. Slides were shown illustrating the various steps in queen breeding. At the close of Dr. Argo's talk members participated in a general discussion.

LUCY W. CLAUSEN, *Secretary*.

## MEETING OF APRIL 6, 1937

A regular meeting of the New York Entomological Society was held on April 6, 1937; President Curran in the chair with twenty-nine members and forty-one visitors present.

The program committee announced that the next meeting would be an open house program by members on collecting notes and exhibition of specimens.

The committee on Junior Membership reported progress and the Chairman, Mr. Kisliuk, hoped to be able to render a complete report at the next meeting.

Dr. William Sargent was proposed for active membership. The by-laws were suspended in order to elect him to membership immediately.

Mr. R. W. Sherman, of Bloomfield, N. J., the speaker of the evening, was then introduced and spoke on "Some Domestic Quarantined Insects." The address consisted mainly of remarks on the control of the Japanese Beetle and its spread since 1916 when it was first discovered by Mr. Harry B. Weiss and Mr. E. L. Dickerson at Riverton, N. J. Since then the U. S. Government had been combating the spread of this pest. At present the quarantine control is still in effect. Two factors govern its activities.

(1) States outside of the infested area wish to be protected from introduction of the pest.

(2) Nurserymen, growers and farmers in the infested area wish to have outlets for their produce and wares. In order to meet these two demands quarantine experts are forever on the lookout for infested stock leaving the territory of infestation.

Mr. Sherman's talk was illustrated with motion pictures showing all the methods of control of the Japanese Beetle on both a large and small scale.

There was a general discussion of Mr. Sherman's paper.

## MEETING OF APRIL 20, 1937

A regular meeting of the New York Entomological Society was held on April 20, 1937; Vice-president Moore in the chair with twenty-two members and fourteen visitors present.

The program committee reported that Dr. Daniel Ludwig of New York University would speak at the next meeting on "The Physiological Varieties of the Japanese Beetle—as determined by environmental factors," illustrated by lantern slides.

Dr. Lutz informed the Society of the death of Professor William Morton Wheeler.

The rest of the meeting was devoted to notes by members.

LUCY W. CLAUSEN, *Secretary*.

## MEETING OF MAY 4, 1937

A regular meeting of the New York Entomological Society was held on May 4, 1937; President Curran in the chair with twenty-five members and fifteen visitors present.



The committee on Junior membership reported that it would give a full report in the fall.

Dr. Daniel Ludwig of N. Y. U., the speaker of the evening, pointed out that in nature it makes little difference whether the beetles (Japanese Beetles) pass the winter as 2nd or 3rd instars since the time of emergence is practically the same. Reaction of larvæ to food and temperature are very complicated.

There is a diapause in the Japanese beetle grub, the position of which varies with temperature and food.

A general discussion of Dr. Ludwig's paper brought the meeting to a close.

LUCY W. CLAUSEN, *Secretary*.

#### MEETING OF MAY 18, 1937

As previously announced there was no formal meeting. Members and guests indulged in informal discussions. Refreshments were served.

The following were proposed for active membership: Mr. Randolph Latta, Box 786, Babylon, L. I., and Mr. George Osterman, N. Y. U., University Heights, N. Y. C. The by-laws were suspended in order to elect them before adjournment for the summer.

LUCY W. CLAUSEN, *Secretary*.



## NOTES ON DIPTEROUS PARASITES OF SPIDERS

BY BENJAMIN JULIAN KASTON

CONNECTICUT AGRICULTURAL EXPERIMENT STATION,  
NEW HAVEN, CONNECTICUT

In the course of some studies carried on at the Osborn Zoological Laboratory, Yale University, I had the opportunity to note a few cases of parasitism of spiders by insects. By far the greater proportion of these parasites are Hymenoptera; a few are Diptera. Diptera bred from egg cocoons have been reported by Coquillett (1892, 1898), Davidson (1894), C. Koch (according to König, 1894), Brues (1902, 1903), Auten (1925), Kintner (1935), and Herms *et al.* (1935). Internal parasites of spiders themselves have been Diptera of the family Cyrtidæ.<sup>1</sup> The members of this family are admittedly uncommon in entomological collections, and naturally specimens are more apt to be reared by collectors of spiders than of Diptera. The first specimen reared was an *Ogcodes pallipes* Erichson from *Clubiona putris* Koch by Menge (1866). Brauer (1869) reared *Astomella lindenii* Er. from *Cteniza ariana* Koch. Emerton (1890) obtained a specimen that proved to be *Acrocera fasciata* Wiedemann from *Amaurobius bennetti* Blackwall. The same species was reared by Montgomery (1903) from *Schizocosa crassipes* (Walckenaer). *Ogcodes doddi* Wandolleck was bred from *Cosmophasis bitaeniata* Keyserling (Wandolleck, 1906). King (1916) gave a very complete account of the life history, and description of all the stages of *Pterodontia flavipes* Gray. The hosts are *Araneus sericatus* Clerck and *Lycosa pratensis* Emerton. Nielsen (1932) reared *Acrocera globulus* Panzer from a *Lycosa* sp., and *Ogcodes gibbosus* Linn. from *Prosthesima* sp.

Johnson (1903) in discussing Montgomery's rearings suggested that "many spiders, perhaps 25 per cent., are thus parasitized." However, it is my opinion that Montgomery's case was unusual. Even spiders bearing hymenopterous larvæ, which are ectopara-

<sup>1</sup> McCook (1890) refers to a *hymenopterous* larva emerging from the body of a spider, but this is probably an error. The specimen was not reared.

sitic and hence easily seen, are seldom encountered in nature. This was pointed out by the distinguished Danish araneologist, Nielsen, who has investigated the life histories of many hymenopterous parasites, yet has reared but two cyrtids. Of the close to a thousand spiders I have kept alive in the laboratory for considerable periods of time during the last four years I found only five so parasitized.

According to Johnson (1915), Montgomery was able to detect those spiders which were parasitized long before the emergence from the host. On the contrary, the spiders I had gave no indications of being parasitized even up to within a day or so of the parasites' emergence, though they were being closely observed almost daily in various experiments. Hence the parasite must grow at a tremendous rate during the last few hours of the host's life.

I am indebted to Dr. C. H. Curran of the American Museum of Natural History for his kindness in determining the flies, and to my wife for the illustrations.

*Ogcodes costatus* Loew.

The host spider was an immature *Lycosa* sp. collected at Orange, Conn., May 9, 1935. It was killed May 22 by the emergence of the parasite larva which had cut its way out through the ventral side of the abdomen near the anterior end (Fig. 1). The cephalothorax and coxæ were eaten out as well as the abdomen, but only the latter was shrivelled. The fully developed larva (Fig. 2) is markedly different in appearance from the corresponding stages figured by Brauer for *Astomella*, by Emerton for *Acrocera*, by King for *Pterodontia*, and by Nielsen for *Acrocera*. It agrees somewhat with the brief descriptions of *Ogcodes pallipes*, and of *O. gibbosus* as given by Menge and Nielsen, respectively. The young stages of cyrtid larvæ have been described by Maskell (1888), König, and King. They differ both in structure and method of movement from the fully developed stages.

The larva was 9.35 mm. long and had a glistening sticky skin which caused particles of debris to adhere to it. There was a small inconspicuous head, light yellow in color. Of the mouth-



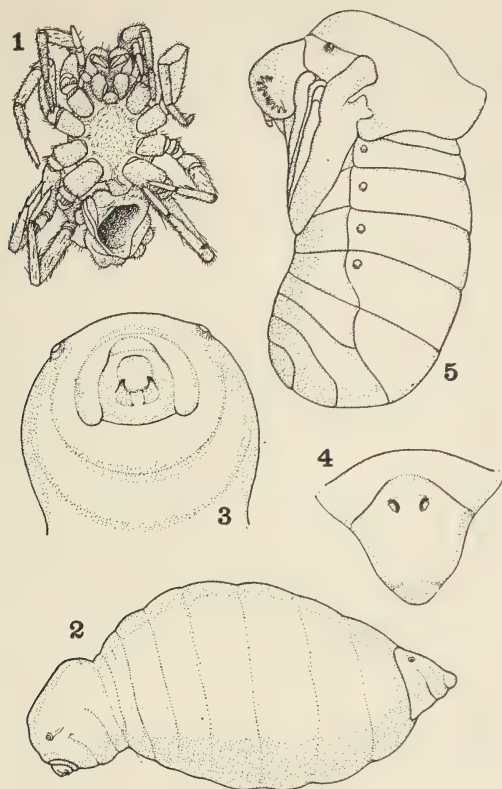


Figure 1. Ventral aspect of *Lycosa* sp. killed by the emergence of *Ogcodes costatus* larva.

Figure 2. Left lateral aspect of *O. costatus* larva after emergence from host.

Figure 3. Ventral aspect of anterior end of larva.

Figure 4. Dorsal aspect of posterior end of larva.

Figure 5. Left lateral aspect of pupa.

parts (Fig. 3) only a pair of darkly pigmented mandibular or oral hooks could be discerned. There was a distinct globular yellowish thorax. Faint indications of its subdivisions were present on the ventral side, and a pair of darkly pigmented spiracles were borne near the dorsal surface of the prothorax. The tracheæ connecting with these were visible for some distance beneath the skin. The abdomen was large, creamy white, and divided into what

appeared to be seven indistinct precaudal segments and a distinct conical upwardly sloping caudal segment. The latter was itself partly divided by two ventral folds, and bore a pair of spiracles on its dorsal surface (Fig. 4).

On May 23 it pupated. The excrements voided before pupation remained as a long, thin, black, curved string extending from the caudal end of the pupa. Malloch (1915) described the pupa of this species and figured the abdomen. Unfortunately his material was very poorly preserved so that the description is not entirely applicable here. The total length was about 6.25 mm., measured from the disc of the prothorax, as the head was bent down considerably on the ventral side of the thorax (Fig. 5). On either side of the head were two sextets of papilliform processes which were pigmented at the tips. In this and in having the posterior three segments (6 to 8) of the abdomen slightly telescoped into the preceding, it resembled *Pterodontia* as described and figured by King. Malloch described the head as being "without discoverable protuberances or hairs," and figured the last segment of the abdomen protuberant. There were a pair of prothoracic spiracles, and a pair on each of the first four abdominal segments, all elevated from the general body surface.

On May 28 the pupa had become quite dark and looked ready to emerge within a day or so. There was very little change in appearance on the succeeding days and on June 1 it was dead. The probable duration of the pupal period is 6 to 7 days.

*Ogcodes pallidipennis* Loew.

According to Cole (1919) an individual of this species in the U. S. National Museum collected by A. A. Girault at Coulterville, Ill., has a label "Bred from cell of *Sceliphron cementarius*. Iss. June 18, 1919." This mud-daubing wasp provisions its nest with very many species of spiders so that the particular host of the parasite cannot be ascertained. In the collection of the Connecticut Agricultural Experiment Station there are two specimens. One label reads "New Haven, Ct., 13 July 1904, P. L. Butrick"; the other, "Pine Orchard [in Branford] Ct., 26 July 1904, H. L. Vierick."

My observations on this species were unfortunately not as detailed as for *O. costatus*, due to press of other matters, nor were any drawings made. However, I can recall that the larva closely resembles that of *costatus*. I have no recollections concerning the pupa. In all four cases which I observed, the parasite left the host through the latter's abdomen, after cleaning out the cephalothorax and coxæ as described for *costatus*.

From an immature *Pardosa banksi* Chamberlin collected at Indian Neck in Branford, Conn., May 17, 1932, the parasite emerged July 1. It was not reared. From a similar specimen collected with the first, the parasite emerged July 16, pupated July 17, and the imago emerged July 22. From a mature female of the same species collected in the same locality June 7, 1933, the parasite emerged July 7, pupated July 8, and the imago emerged July 14. From an immature *Pardosa saxatilis* (Hentz) collected at New Haven, Conn., May 18, 1934, the parasite emerged June 14, pupated June 15, and the imago emerged June 20. This indicates the duration of the pupal period to be 5 to 6 days. All the imagines were very sluggish, not flying at all, and walking about only when poked.

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*Note.* Some time after this manuscript left my hands for the editors I happened upon a note by A. Giard (1894, Sur quelques parasites des araignées, *Bull. Soc. Ent. France*, pp. CLIII-CLV). This author collected a specimen of *Ogcodes pallipes* standing near the pupal skin from which it had recently emerged. Nearby were the remains of a *Clubiona* sp., its host. Mr. K. C. McKeown of the Australian Museum has recently written me that "there are records of unnamed Cyrtidae attacking several species of spiders" in Australia.



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